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PRELIMINARY STUDIES - ARKANSAS RIVER AND TRIBUTARIES, TULSA TO MUSKOGEE, OKLAHOMA

Federal Water Pollution Control Administration
Ada, Oklahoma

February 1966

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ARKANSAS RIVER BASIN

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PRELIMINARY STUDIES
ARKANSAS RIVER AND TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
Arkansas-Red River Basins Comprehensive Project
Ada, Oklahoma

FEBRUARY 1966

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PRELIMINARY STUDIES ARKANSAS RIVER

PRELIMINARY STUDIES-ARKANSAS RIVER AND TRIBUTARIES
Tulsa to Muskogee, Oklahoma

Abstract

An investigation of water pollution control and water quality in the Arkansas River basin between Tulsa and Muskogee, Oklahoma, was carried out during July and August of 1965. Recommendations for water pollution control measures in this reach of the Arkansas River and tributaries which should be implemented in the immediate future are included together with the data and findings of the study.

Prepared at the request of and in cooperation
with the Interagency Water Pollution
Control Coordinating Committee
State of Oklahoma

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Federal Water Pollution Control Administration
Arkansas-Red River Basins Comprehensive Project

Ada, Oklahoma

FEBRUARY 1966

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COOPERATING AGENCIES

State of Oklahoma

- Department of Health
- Water Resources Board
- Corporation Commission
- Department of Wildlife Conservation
- Department of Agriculture

Tulsa County

- Health Department

City of Tulsa

- Engineering Department
- Water and Sewer Department

Corps of Engineers

U.S. Geological Survey

Federal Water Pollution Control Administration

- Region VII, Dallas, Texas
- Robert S. Kerr Water Research Center

The two former reports relate to the value of storage in multipurpose reservoirs for water supply and water quality control by flow regulation, while the latter concerns control of chloride pollution in the Arkansas-Red River Basins.

During the summer of 1964, a study of water quality and sources of potential pollution in the Arkansas River from Keystone Reservoir downstream to Jenks, Oklahoma was carried out in cooperation with the Oklahoma State Department of Health and the Interagency Water Pollution Committee. That cooperative study was initiated as the result of the following resolution by the Oklahoma State Interagency Water Pollution Control Coordinating Committee passed unanimously on January 7, 1964:

"That the Committee go on record to undertake a study on the Arkansas River to determine present pollution sources, to define the problem, and to project the probable effect of that pollution in the light of the expected improvement of the river by turning it into a series of low-water dam impoundments, and the consequent improvements of the waterfront on both sides of the river in the Sand Springs-Tulsa area ", and a request for assistance from the Public Health Service in coordinating a technical study.

The objectives of the investigation were: (1) To evaluate the effect of waste loads discharged to the Arkansas River upon water quality on the basis of expected minimum discharges from the Keystone Reservoir and hydroelectric plant. (2) To evaluate the effect of ponding on river water quality in terms of its possible use for recreational purposes in the Tulsa metropolitan area. A report, ARKANSAS RIVER, Preliminary Studies, Tulsa Metropolitan Area, dated September 1964, presents the findings. 4/

The 1964 study (first phase) on the Arkansas River from Keystone Reservoir to Jenks, Oklahoma, together with this investigation (second phase), covers approximately two-thirds of the area between Keystone Reservoir and the State line (Arkansas).

OBJECTIVES

The overall objective of the investigation undertaken in the reach of the Arkansas River extending from Tulsa, Oklahoma to the State line (Arkansas) is to provide data for the preparation and development of a comprehensive program for controlling or eliminating pollution.

The objective of this Interim Report is to present the data and findings of the phase of the overall study completed during the summer of 1965 together with recommendations for water pollution control in this reach of the Arkansas River and tributaries which can be implemented in the immediate future.

METHODS

Field work for this second phase included measurement of the major waste loads presently discharged to the main stem of the Arkansas River or its major tributaries, and examination of stream samples collected at various points beginning with the Arkansas River bridge at 51st Street in Tulsa, and extending downstream to Muskogee, Oklahoma. Similar sampling and investigative procedures were carried out on the Verdigris River, Bird Creek and tributaries, Caney River, and the Grand (Neosho) River. The study area and sampling locations are shown on Figure 1, at the back of the report, and detailed sampling station descriptions are shown in Appendix A.

Major field sampling and analytical work started July 7, 1965, and concluded August 18, 1965, with special benthic samples being collected on October 6, 1965 to supplement those taken during the summer sampling program. In addition to the stream and effluent sampling program, data on municipal and industrial wastes production and treatment were gathered to the extent which the municipalities and industries made such records and information available.

In the field, as the samples were collected, rainfall (if any), water temperature, air temperature, pH, dissolved oxygen, and the presence of oil or grease were noted.

In the laboratory, stream samples were examined for BOD, COD, N as Total Kjeldahl, NH_3, NO_2, NO_3, Total PO_4, Cl, Coliform MPN, and Fecal Coliform MPN.

Municipal water pollution control plant samples were analyzed for all of the above except coliform and fecal coliform.

All laboratory procedures were in accordance with Standard Methods for Examination of Water and Waste Water, 11th Edition, 1960. 2/

Minor waste flows were estimated, major waste flows were measured, and streamflows were measured at the Tulsa and Muskogee gages on the Arkansas River, Inola and Claremore gages on the Verdigris, Avant and Sperry gages on Bird Creek, and the Ramona gage on the Caney River.

RESULTS OF INVESTIGATION

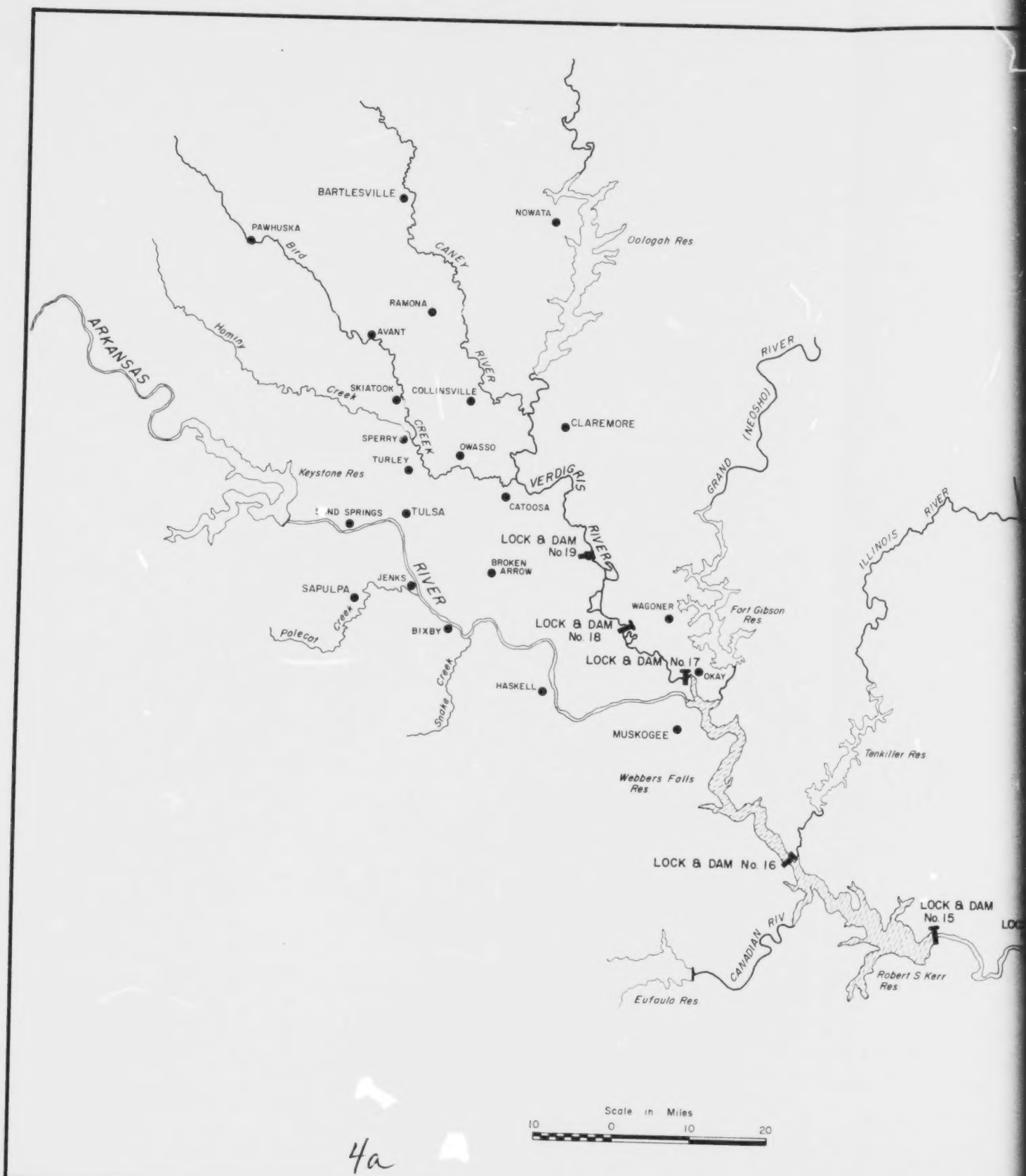
The analytical and physical data, together with the waste production and treatment inventory, will provide a base for analysis of future conditions. However, consideration of the effects on water quality of modifications to the Verdigris and Arkansas Rivers to provide for navigation must be based on expected flow and channel characteristics of the proposed navigation project. Figure 2 shows the general location of proposed channel modifications within the study area and their relationship to adjoining stream reaches.

Waste Discharge Inventory

A total of 22 industrial water users in the study area were canvassed concerning waste disposal practices. Tabulations of the information obtained are contained in Appendix B. Table 1 summarizes these findings.

Municipal water pollution control plant information for the study area, Appendix C, was obtained from field investigation of all plants in the study area by members of the survey team. Table 2 summarizes these data.

Long-term operating data (1963 to date) were obtained from various municipal water pollution control plants. These data are compiled in Appendix D and summarized in Table 3. Likewise, results of analyses of samples collected at water pollution control plants in the area studied are summarized in Table 4, with details in Appendix E.


BARTLESVILLE
NOWATA
PAWHUSKA
Bird
CANEY
Oologah Res
RAMONA
AVANT
Hominy
RIVER
ARKANSAS
Creek
SKIATOOK
COLLINSVILLE
CREEK
CLAREMORE
SPERRY
OWASSO
TURLEY
Keystone Res
VERDIGRIS
GRAND (NEOSHO) RIVER
CATOOSA
TULSA
LOCK & DAM No.19
RIVER
BROKEN ARROW
ILLINOIS RIVER
JENKS
SAPULPA
RIVER
WAGONER
Fort Gibson Res
Creek
Polecat
BIXBY
LOCK & DAM No. 18
LOCK & DAM No. 17
OKAY
Snake Creek
HASKELL
MUSKOGEE
Tenkiller Res
Webbers Falls Res
LOCK & DAM No. 16
LOCK & DAM No. 15
CANADIAN RIV
Robert S Kerr Res
Eufaula Res
Scale in Miles
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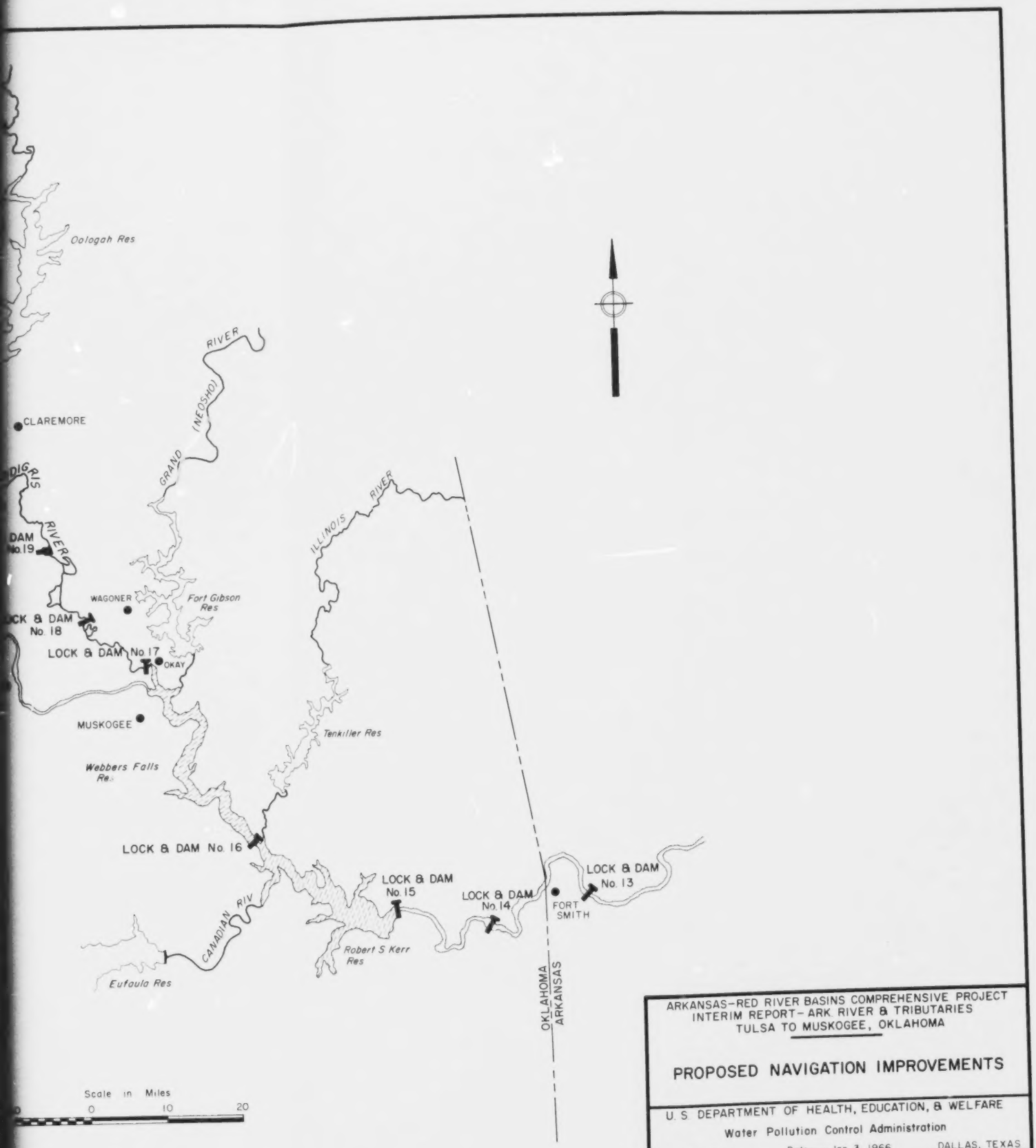


ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT- ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

PROPOSED NAVIGATION IMPROVEMENTS

U. S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Water Pollution Control Administration
REGION VII Date---Jan. 3, 1966 DALLAS, TEXAS

FIGURE 2

TABLE 1
SUMMARY

INDUSTRIAL WATER USE AND WASTE RELEASES

	Location			
	Barnsdall	Bartlesville	Muskogee	Tulsa
Water Intake - MGD				
Cooling	0.144	0.703	0	5.354
Process	0.516	0.373	0.650	9.219
Total	0.720	1.076	0.650	14.573
Discharge - MGD				
Treated	0	0.517	0.355	7.143
Untreated	0.144	0	0.295	1.644
Total	0.144	0.517	0.650	8.787
Point of Release	Bird Creek	Caney River	Arkansas River	Mingo Crk. (0.610 mgd) City San. Sewer (1.633 mgd) Ark. River (6.221 mgd) Wells (0.323 mgd)

TABLE 2
SUMMARY

CURRENT MUNICIPAL WATER POLLUTION
CONTROL PRACTICES IN STUDY AREA

Number of Towns		31
Number of Plants		28
Primary Type	3	
Secondary Type	16	
Lagoons	9	
Towns with Municipal septic tanks		6
Primary Treatment (mgd)		17.58
Secondary Treatment (mgd)		43.586
Lagoon Treatment (mgd)		.947
No Treatment* (mgd)		.319
TOTAL		62.432

*Bixby provides no treatment. Jenks and Barnsdall - Although septic tanks provided, a portion is discharged without treatment.

TABLE 3
SUMMARY

LONG-TERM MUNICIPAL WASTE RELEASES
CITY OF TULSA WATER POLLUTION CONTROL PLANTS

Plant	Year	Temp. °C	Annual Average Effluent (mg/l) D.O. Avg.	BOD 5-Day	Flow (mgd)
Coal Creek	1963			77	3.2
	1964			78	2.4
	*1965			74	2.8
Flat Rock	1963			73	3.7
	1964			86	3.7
	*1965			71	4.4
North Side	1963			14	3.54
	1964			13	4.15
	**1965			18	4.7
South Side	1963	22.5	0	122	12.1
	1964	22.2	0	144	11.4
	**1965	20.2	0	149	13.2

*Records through July 1965.
**Records through June 1965.

Stream Survey

During the survey, streams in the area were below mean annual flow, which normally occurs during this time of the year. Supersaturation of dissolved oxygen was observed at various stations during daylight, notably all sample stations on the Arkansas River and stations 205 and 209 on the lower Verdigris River. Results of the analyses are summarized in Table 5, while results of individual sample analyses are detailed in Appendix E.

Bacteriological Analyses

The results of bacteriological sampling indicated ranges in total coliform from 42 to 5,000 per 100 milliliter in the Arkansas River between Tulsa and Muskogee during the period of survey. Results of analyses for the other streams are summarized in Table 6 with details of sampling procedure and analysis in Appendix A and E.

TABLE 4
SUMMARY*

SAMPLES COLLECTED AT WATER POLLUTION CONTROL PLANTS

No.	Location**	Temp. °C	D.O. (mg/l)	B.O.D. 5-day (mg/l)	C.O.D. (mg/l)	Nitrogens (mg/l) Total Kjeldahl	NH_3	NO_2	NO_3	Phosphate (mg/l) Total	Ortho	pH	Cl (mg/l)
79	South Side WPCP*** Effluent	28.3	0	151	340	23.08	20.70	.04	.02	47.0	32.5	7.1	92
89	Sand Springs WPCP Effluent	27	4.0	100	319	39.72	32.8	.22	3.9	75.0	22.5	7.5	90
113	Sunray DX WPCP Effluent	50	2.5	27	122	15.52	15	.03	0	.8	2	10.3	112
167 & 168	Coal Creek WPCP Effluent	26	3.8	53	265	17.34	13.0	.34	3.5	57.5	40	7.6	55
171	North Side WPCP Effluent	27	1.9	10	72	6.6	2.7	.60	35.1	69	57.5	7.5	81
172	North Side WPCP Raw Sewage	26.1	0	193	546	24.73	21.87	.13	0	76.1	61.8	7.5	70
173	WPCP Stabilization Pond Effluent	30	14	20	228	8.69	6.44	.08	.17	16	7.5	9	40
175	Flat Rock WPCP Raw Sewage			164	596	29	25.8	.016	1.765	52.5	51	7.6	175
176 & 177	Flat Rock WPCP Effluent	13.6		67	272	22.47	20.46	.05	.84	58	45	7.5	164
178	Sperry WPCP Effluent	25.3	3.36	21	113	15.3	7.9	1.8	4.2	35.0	35	7.2	93
180	Skiatook WPCP Effluent From Lagoons	28	14	24	203	17.17	9	.07	5	35	24	8.5	92
182	Owasso WPCP Lagoons Effluent			32	179	2.87	.84	.03	0	7.5	2.5	9.7	74
185	Collinsville WPCP Effluent	27.7	2.5	23	113	29.04	27.84	.03	.05	77.5	45.8	7.1	157
186	Tulsa Rendering Plant WPCP Lagoons Effluent	29	14	24	176	18.72	11.44	.30	.08	16.5	5.5	9.2	226
187	Barnsdall WPCP Effluent	27	0	213	609	39.57	34.53	.02	.15	130	52.5	6.6	100
188	Pawhuska WPCP Effluent	27.3	1.5	35	109	18.23	8.1	1.6	6.26	51.7	30	6.9	80
189	Claremore WPCP Effluent	28	3.8	20	96	17.18	10.7	.55	4.1	50	35	7.1	197
201	Bartlesville WPCP Effluent	28	1.1	56	235	15.53	14.54	.08	2.24	42.5	25.0	6.8	135
202	Washington County WPCP Effluent	31.5	20.6	9	56	2.70	0	.24	1.45	5.6	1.9	9.4	367
203	Wagoner WPCP Effluent	28.2	2.0	20	80	19.89	12.0	0.56	5.6	71.2	59.1	7.1	75
212	Muskogee WPCP Effluent	27.8	1.1	105	288	20.28	17.5	.09	.28	44.1	27.2	7.0	80
213	Rolling Hills WPCP Effluent	28	14	26	264	20.36	17.6	.09	.17	95	79.4	8.5	80
214	Taft WPCP Effluent	29.5	1.3	86	185	16.46	11.5	.55	2.45	27.5	11.3	6.8	37
215	Haskell WPCP Effluent	27.3	7.7	27.3	144	3.16	1.29	.19	17	21.5	18.5	7.9	45
216	Sapulpa WPCP Effluent	27.3	3.4	21	145	21.25	7.8	.51	11.2	71.7	57.0	6.8	129

*Averages for the period of study (Summer, 1965).
**Description of sampling points appended, Table A-1.
***WPCP - Water Pollution Control Plant.

TABLE 5

SUMMARY *

ANALYSES OF STREAM SAMPLES

No.	Stream	Mile	Temp °C	D.O. mg/l	5 day B.O.D. mg/l	C.O.D. mg/l	Nitrogens mg/l				Phosphate mg/l		pH	CO2 mg/l
							Total Kjeldahl	NH_3	SO_2	NO_3	Total	Ortho		
117	Arkansas River	519.7	27.3	9.4	4.0	40	.31	0	.03	0	1.4	.8	8.3	237
116	Arkansas River	514.8	26.8	10.3	4	33.8	.34	0	.05	0	1.4	.8	8.3	246
137	Arkansas River	457.8	30.8	8.8	5.8	21	.61	0	2.4	.2	1.5	.5	8.6	162
138	Grand Neosho River	6.6	29	6.8	2.6	5	.75	0	0.3	.44	.65	.3	8.1	18
139	Verdigris River	48.8	29.8	6.8	3	9	.56	0	.04	.13	1.90	1.2	7.4	132
141	Hominy Creek	16.8	30	7.7	4	39	.53	0	.01	.07	.73	.07	7.6	329
142	Bird Creek	54.2	30	7.5	4	17	.38	0	.01	.07	.77	.23	7.7	41
143	Verdigris River	76.0	28.9	7.4	5.4	14	1.94	.9	.07	.6	1.1	2.5	8.1	108
154	Joe Creek	515.2	25.6	7	5	94	.93	0	.03	.42	.7	.2	7.3	1305
158	Haikey Creek	502.8	26	7.8	4	28	2.81	0	.06	.45	4.2	3.23	7.8	145
160	Snake Creek	504.9	29	7.9	5	14	.34	0	.03	.05	.7	.3	7.6	124
162	Polecat Creek	513.6	27	8.5	6	66	.30	0	.02	0	.7	.1	7.7	426
190	Dog Creek	55	29	3.8	6	22	.64	.2	.09	.12	6.2	4.6	7.0	63
191	Bird Creek	2.8	28.2	3.6	4	30	2.04	.40	.20	.84	4.4	3.6	7.2	112
192	Caney River	3±	29	6.5	3.2	15	3.69	2.92	.04	.24	.67	.28	7.7	151
193	Verdigris River	90	28.3	6.8	3.7	12	.58	0	.02	.18	.97	27	7.4	47
194	Bird Creek	21.8	29.3	7.1	3.3	32	.79	0	.03	.30	1.4	.5	7.5	121
196	Caney River	67±	28.3	5.5	11.3	54	3.48	2.26	.12	.56	16.5	.29	7.2	193
197	Caney River	15.8	28.4	6.46	3	19	.4	0	.03	.15	1.1	.2	7.4	184
199	Horsepen Creek	15.4	29	7.3	7	43	.43	0	.05	.1	1.1	.1	7.5	93
200	Bird Creek	75	28	7.3	5	21	.8	0	.05	.3	1.6	.7	7.5	48
203	Roas Creek	8	28.2	2	20	80	19.89	12	.56	5.6	71.2	59.1	7	75
204	Coal Creek	11.3	28	4.5	8	46	.82	.12	.05	.2	4	3.6	7	158
205	Verdigris River	3.6	31.5	9.6	5.8	27	.44	0	.03	.05	.7	.4	8.2	28
207	Arkansas River	491.1	27	10.3	7	15	.34	0	.025	.0	1.2	.7	8.75	212
208	Arkansas River	466.2	29.2	8.3	7.0	43	.39	0	.02	.07	1.44	.62	9.2	2.7
209	Verdigris River	22.3	29.3	7.8	4	5	.44	0	.03	.03	.61	.37	8.1	113
210	Haikey Creek	7±	26.6	3.1	39	95	27.07	10.63	11.26	5.86	47.5	38.8	7.2	7
211	Polecat Creek		26	6.6	3	41	.95	.16	.05	.3	1.37	1.11	7.6	130

* Averages for the period of study.

TABLE 6
SUMMARY*

BACTERIOLOGICAL ANALYSES

Stream or River	Station	River Mile	Coliform Bacteria-MPN/100ml Geometric Avg. Fecal	Total
Bird Creek	200	75	39,040	122,340
	142	54.2	445	960
	194	21.5	2,323	4,425
	191	2.8	2,021	4,621
Caney River	196	67.0	6,783	16,044
	197	15.8	154	810
	192	2.8	369	800
Verdigris River	193	90	187	686
	143	76	24	51
	139	48.8	71	115
	209	22.3	43	133
	205	3.6	38	55
Arkansas River	117	519.8	2.873	4,400
	207	491.2	130	240
	208	466.2	6	50
	137	457.8	16	29

*Averages for period of study.

Benthic Conditions

Benthic organisms were examined and evaluated to classify stream conditions in the area as clean, moderately polluted, or very polluted. The findings of this portion of the investigation are summarized in Table 7. Details concerning methodology and variety of organisms found are shown in Appendix F.

TABLE 7
SUMMARY

BENTHIC ANALYSIS

Stream or River	Station	River Mile	Biotic * Index	Degree of Pollution	% Observed Organisms		
					Clean	Facul-tative	Pollution Tolerant
Bird Creek	200	75.0	11	Clean	89	11	-
	142	54.2	9	Clean	94	4	2
	179	42.0	2	Moderate	-	40	60
	191	2.8	4	Moderate	14	86	-
Caney River	144	32.0	9	Clean	88	11	1
Verdigris River	193	90.0	10	Clean	78	8	14
	143	76.0	10	Clean	88	7	5
	139	48.8	1	Moderate	-	100	-
	209	22.3	13	Clean	91	6	3
	205	3.6	6	Moderate	90	10	-
Arkansas River	117	519.8	7	Moderate	2	89	9
	116	514.8	-	Moderate	-	-	-
	207	491.2	1	Moderate	-	100	-
	137	457.8	13	Clean	85	13	2

* Always clean ->10
Clean but potentially polluted - 7 to 9
Moderately polluted - 1 to 6
Polluted - 0

Deoxygenation and Reaeration Rate Constants

The coefficient of deoxygenation (k_1) was derived from the survey results by two methods - the moment method and the daily difference method. Both methods are described in Appendix G. The average k_1 of the two methods of calculation was tried in computing the biochemical oxygen demand (BOD) load at various sampling stations. Computed BOD loading (L) was then compared with measured L and k_1 adjusted to provide a compatible fit to the deoxygenation curve. Also, the coefficient of reaeration (k_2) for each of the various major reaches of stream within the study area was determined. These computation are summarized in Table 8.

The computation of deoxygenation and reaeration constants requires the use of stream discharge, velocity, and time of travel. Stream discharge data were obtained from the various U. S. Geological Survey (U.S.G.S.) and Corps of Engineers gaging stations in the study area. Velocity and time of travel factors were developed from U.S.G.S. discharge data and stream cross sections furnished by the U. S. Army Corps of Engineers, Tulsa District Office.

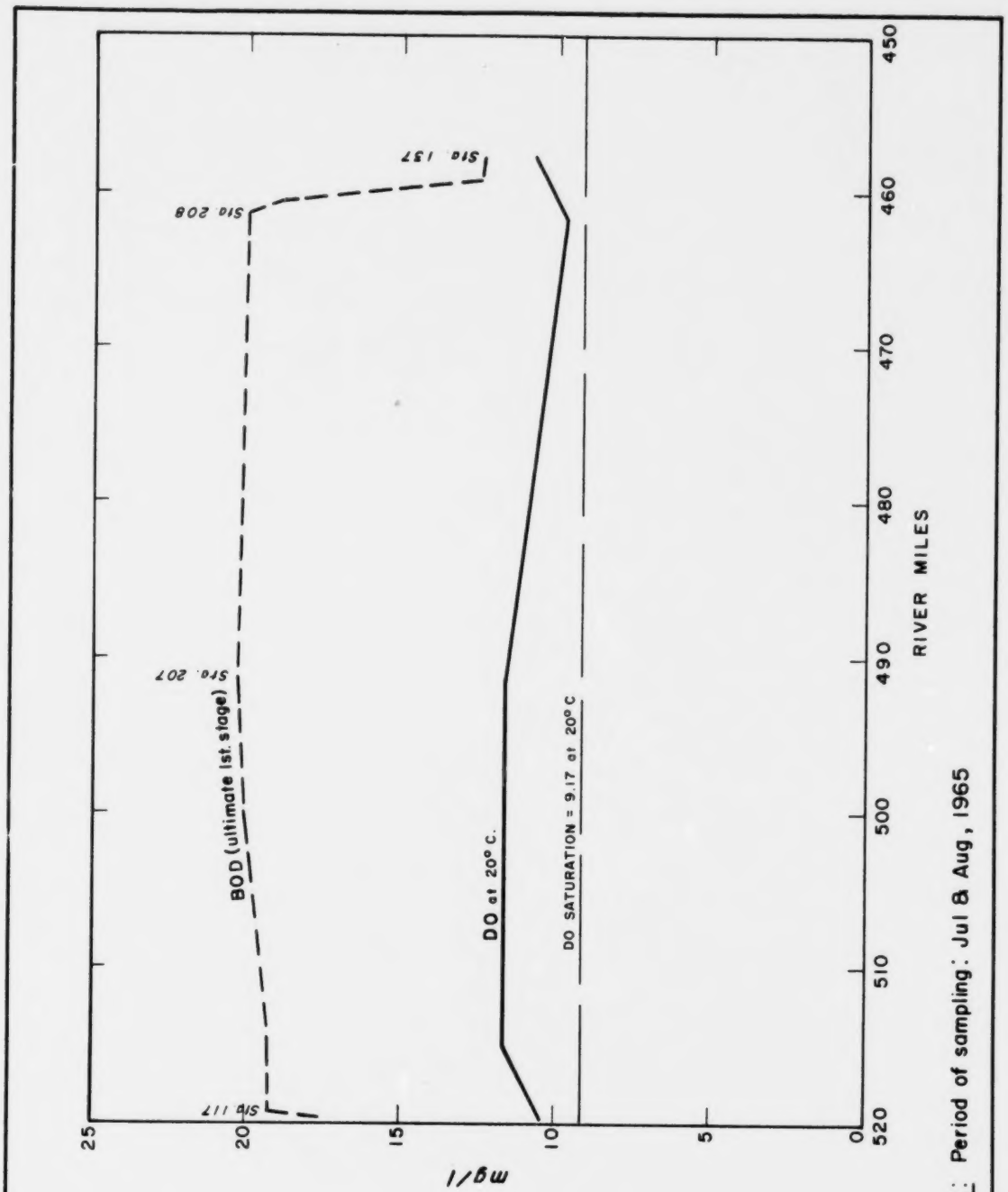
Figures 3, 4, 5, and 6 depict changes in D.O. and BOD levels along the major stream reaches of the study area.

PROJECTED CONDITIONS

Two major factors are expected to affect the quality of the watercourses of the study area. The first is the modification of the channels and control of discharge of the Arkansas and Verdigris Rivers to provide for navigation. (See Figure 2.) The second is the anticipated growth of municipal and industrial waste production and release to the watercourses of the study area. In addition, water quality will be affected by changes in land use resulting in alterations to the quality and quantity of runoff and expected water quality control releases from proposed Corps of Engineers multipurpose reservoir projects.

Effects of Channel Modification on Water Quality

Reaeration constants (k_2) for streams outside the navigation project will be unchanged. Expected k_2 values for the modified



NOTE: Period of sampling: Jul & Aug, 1965

ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT—ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

BOD AND DO PROFILES
ARKANSAS RIVER

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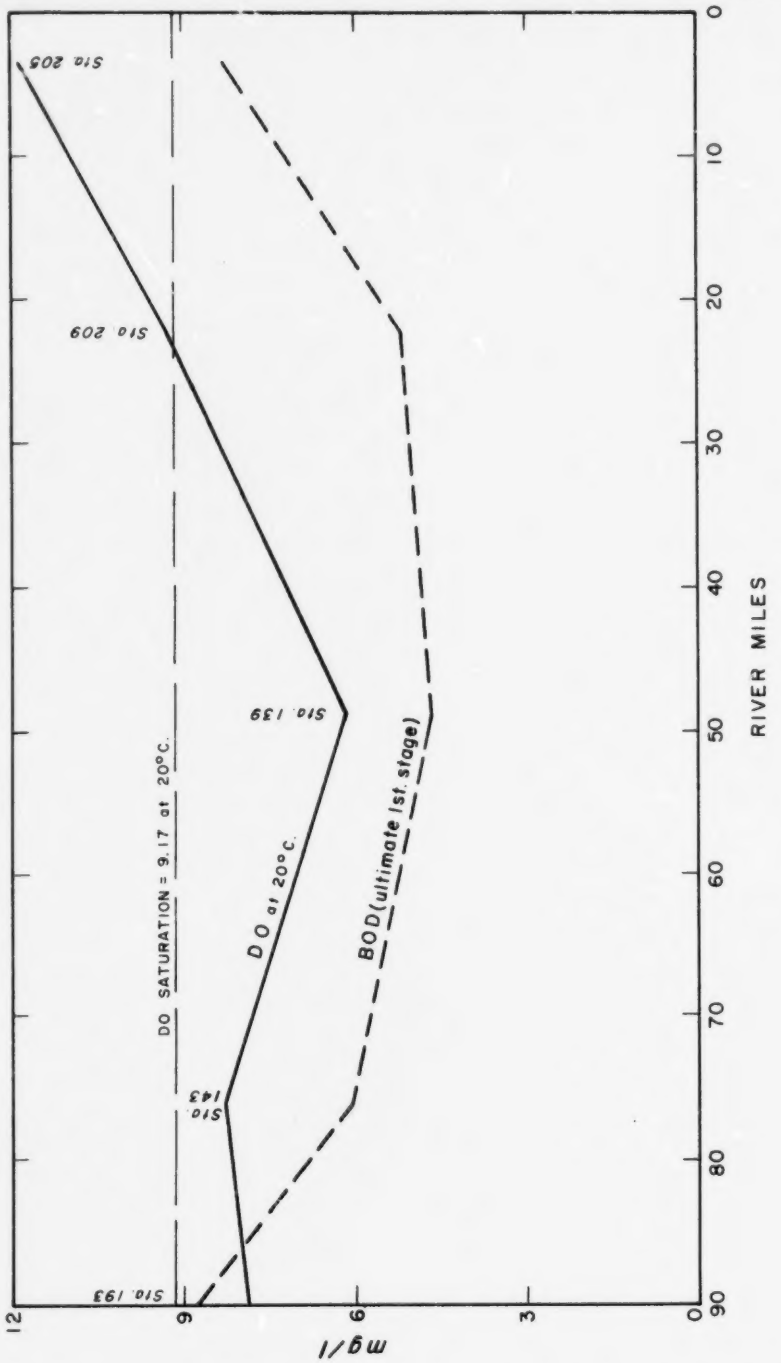
11a

FIGURE 3



NOTE: Period of sampling : Jul & Aug, 1965

ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
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TULSA TO MUSKOGEE, OKLAHOMA

BOD AND DO PROFILES
VERDIGRIS RIVER

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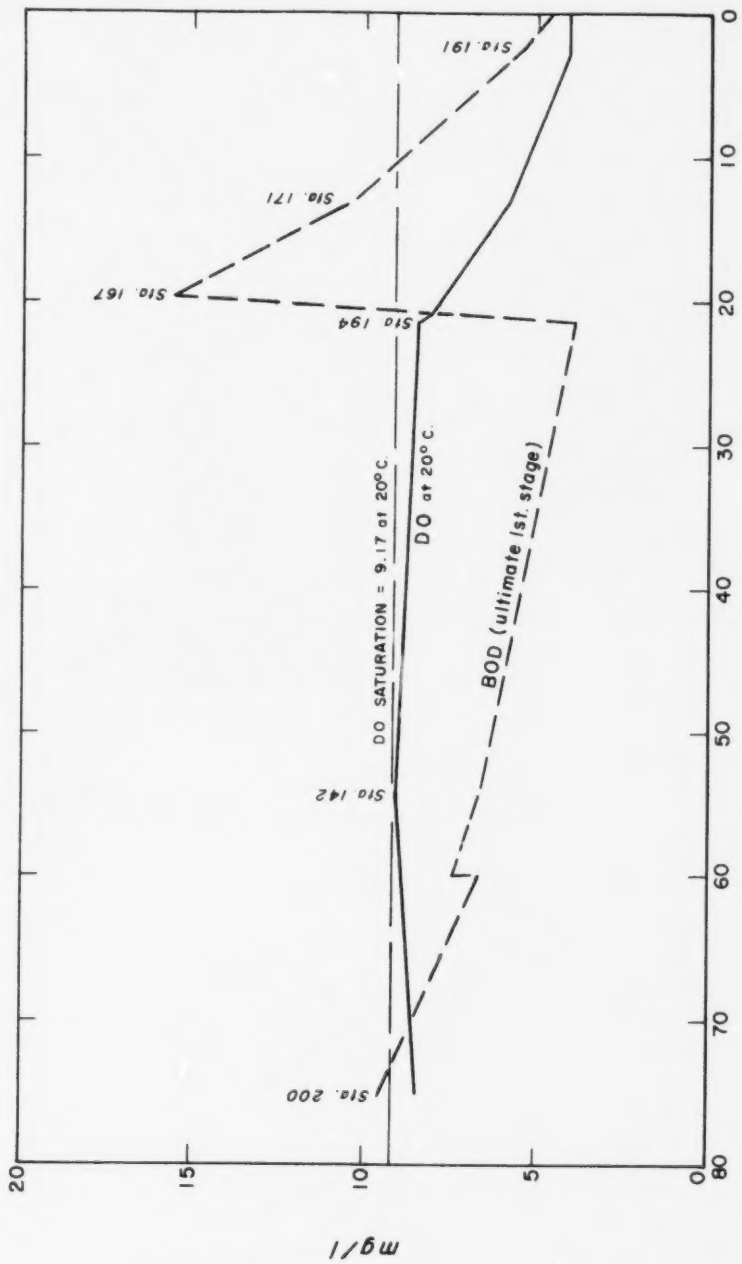
FIGURE 4



NOTE: Period of sampling: Jul & Aug, 1965

ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT–ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

BOD AND DO PROFILES
BIRD CREEK

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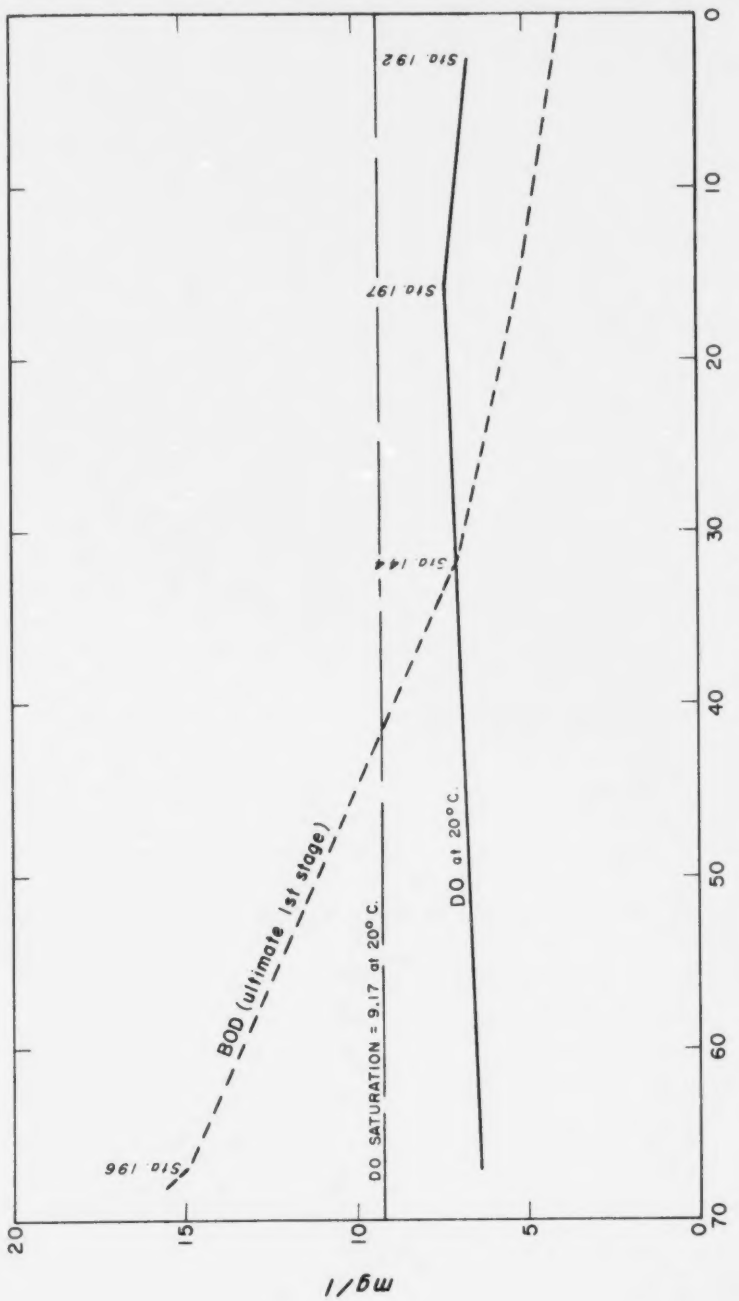
11c

FIGURE 5



NOTE: Period of sampling: Jul & Aug, 1965

ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT—ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

BOD AND DO PROFILES
CANEY RIVER

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11d

FIGURE 6

channels of the Arkansas and Verdigris Rivers were computed from the O'Connor and Dobbins [4] formula $k_2 = (D_L U)^{\frac{1}{2}}/2.31h^{3/2}$ where:

k_2 = Reaeration constant per day at 20°C

U = Velocity in ft./day

h = Effective depth

D_L = Molecular diffusivity constant = 0.00195 ft.^{2}/day oxygen in water

Cross sections of the proposed navigation channel furnished by the Corps of Engineers were used to estimate expected values of k_2 which ranged from a minimum of 0.0683 to a maximum of 0.0872 at 20°C.

A comparison of existing (Table 8), and expected reaeration constants (k_2) in the stream reaches effected by the proposed navigation project shows a decrease. This decrease will reduce the stream's capacity to assimilate treated wastes released to it. However, the controlled releases for navigation will increase minimum flows and thus increase dilution of waste. Reaeration constants along the navigation project will vary appreciably when compared with existing conditions as the effective depth and velocity will be held within rather narrow limits to facilitate navigation. Effective depth will be increased and velocity will be decreased from existing conditions.

The channel improvements for navigation should result in reduced turbidity in the waters of the project. Much suspended material will be removed in the upstream reservoirs serving the project, such as Keystone and Oologah. In addition, the reduced velocities along the project proper will result in settling-out of suspended solids. This may result in increased algae production in the presence of sufficient nutrient (nitrate and phosphate) and sunlight. An overabundance of algae resulting from prolific growth can cause nuisance conditions in water by forming unsightly masses of scum, producing foul odors, or depositing ugly mats on beaches and shoreline. A discussion of the occurrence and effect of algae nuisance problems is contained in Appendix H.

The head of navigation at Catoosa will be materially affected by the quality of Bird Creek. As shown in Tables 5 and 7, and Figure 5, the lower reaches of the stream are degraded by treated waste releases from the Tulsa area water pollution control plants. Navigation channel modifications will result in slowing the recovery from degradation.

TABLE 8
SUMMARY

STREAM CONDITIONS AFFECTING DISSOLVED OXYGEN

No.	River Mile	Flow (cfs)	La (mg/l)	k_1	k_2	BOD 5-day (mg/l)	DO @ 20°C (mg/l)
			BIRD CREEK STATIONS				
200	75.0	30	9.5	.058		4.7	8.4
(187)	60.0	38.5	(6.8-7.4)		.232	-	-
142	54.2	41.5	6.7	.058		4.0	9.0
					.334		
194	21.2	59.0	4.0	.137		3.3	8.4
(167)	19.9	72.0	(15.6)		.137	-	-
191	2.8	84.0	5.5	.100		4.0	4.2
			CANEY RIVER STATIONS				
196	67	219	15.1	.120	.359	11.3	6.5
197	15.8	379	5.2	.089	.312	3.3(w)	7.5
192	2.8	420	4.2	.104	.351	3.6(w)	7.7
			VERDIGRIS RIVER STATIONS				
193	90.0	364	8.8	.048		3.7	7.9
					.095		
143	76.0	834	6.1	.063		3.1(w)	8.3
					.129		
139*	48.8	940	4.7	.089		3.0	6.2
					.137		
209*	22.3	904	5.2	.098		4.0	9.3(s)
					.374		
205*	3.6	879	8.3	.106		5.8	11.9(s)
			ARKANSAS RIVER STATIONS				
117	519.8	8,811	17.6	.022		3.9	10.4(s)
					.480		
116	514.8	8,710	19.4	.020		4.0	11.7(s)
					.502		
207	491.2	8,142	20.4	.037		7.0	11.7(s)
					.165		
208	466.2	7,434	20.1	.037		7.0	9.8(s)
					.163		
137*	457.8	16,750	12.4	.053		5.8	10.7(s)

(187,167) - Calculated values at these locations rather than actual stream measurement.

(w) - Weighted average.
* - Future navigation areas.
(s) - Supersaturated condition.
Note: k_1 and k_2 to the base 10.

Existing and Anticipated Water Uses

Water quality requirements vary within the study area according to existing and expected uses. Table 9 summarizes these uses by stream and reach. Water quality requirements are discussed in Appendix I.

DISCUSSION

Both the analytical and biological analyses indicated areas where existing pollution was degrading stream quality. A serious pollution condition existed in Bird Creek during the time of the study. Of the water pollution control plants located on the Bird Creek watershed, only the Northside plant of the City of Tulsa was providing adequate treatment. As shown on Figure 5, Bird Creek had recovered, having reduced the BOD load imposed in the upper reaches by poor treatment at Barnsdall and maintained the DO near to saturation, at the point (station 194) just upstream from the three City of Tulsa water pollution control plants. The effect of the releases from these plants on the stream is a marked increase in BOD and a gradual decline in DO. Indications are that even though secondary treatment is provided at these plants, the stream will be unable to assimilate this quantity of effluent during low streamflows without excessive degradation.

TABLE 9
SUMMARY

PRESENT AND ANTICIPATED WATER USES

Stream	Reach	Use(s) to be Protected*
Arkansas	Mile 519.7 to Mile 460.2	2(a), 4, 5, 7, & 9
	Mile 460.2 to Mile 456 ± (End of Study Area)	2(a), 4, 5, 7, 8, & 9
Verdigris	Mile 90.2 to Mile 63.6	1, 2, 3, 4, 5, 7, & 9
	Mile 63.6 to Mile 0.0	1, 2, 3, 4, 5, 7, 8, & 9
Bird Creek	Mile 85.0 to Mile 0.0	3, 4, 5, 7, & 9
Caney River	Mile 68.3 to Mile 0.0	3, 4, 5, 7, & 9

*List of uses to be protected. General requirements appended.
1. Domestic Water Supply
2. Industrial Water Supply - (a) Cooling Water Only
3. Irrigation
4. Stock and Wildlife Watering (including Refuge for Waterfowl)
5. Propagation of Fish and Other Aquatic and Marine Life
6. Swimming, Bathing, and Other Water Contact Sports
7. Boating and Aesthetic Enjoyment
8. Water Power and Navigation
9. Transport, Dispersion, and Assimilation of Wastes

It is of interest to note the situation regarding streamflow during the study. Within 49 stream miles, the monthly average discharge of the Verdigris River declined from 940 cfs to 874 cfs between mile 48.8 and the mouth. A similar condition existed on the Arkansas River between Tulsa and Muskogee, the discharge (monthly average) decreases going downstream. BOD loadings, time of travel, and related factors were adjusted as required. This unusual condition apparently results from low runoff and high evaporation rates during this season, as well as possible seepage.

An anomaly occurred in the lower reach of the Verdigris River during the period of study. BOD concentration tended to increase gradually from river mile 48.8 downstream rather than decreasing as

took place upstream from this point. This increase in concentration can not be ascribed to the decrease in flow encountered. BOD concentration entering at this point from Bird Creek approximated that in the Verdigris River. Indications are that Bird Creek's dissolved oxygen profile had passed the critical point and was recovering at the confluence with the Verdigris River (under the waste loading and flow conditions encountered during this study).

The data gathered during this study indicates the presence of an additional source or sources of BOD in the reach of the Verdigris River downstream from mile 48.8 to its confluence with the Arkansas River. The current survey was not planned to investigate a situation such as this as there are no apparent sources in that reach other than sewage from the Town of Wagoner, which was a part of the survey. Further investigation of these findings can be carried out during the next phase of the study.

This study points up the existing difference and deficiencies in waste assimilative characteristics in the major streams of the Arkansas River basin between Tulsa and Muskogee. The reaeration constant (k_2) which is the controlling factor in replacement of dissolved oxygen used in waste stabilization can be altered in several ways. These are inter-related changes in flow rate, velocity, and channel shape (depth). Releases for navigation or power from Keystone and Oologah Reservoirs can result in improved conditions in the Arkansas and Verdigris Rivers by providing dilution and increased velocity of flow. Quality conditions in Bird Creek will be unaffected by the releases from these reservoirs.

Improvements of quality conditions in Bird Creek can be achieved in a number of ways. Principally these are:

a. Withhold waste from the stream by discharging after adequate treatment to another stream having greater flow and/or better recovery characteristics.

b. Withhold adequately treated waste from the stream during periods of low stream flow for release when the stream will not be adversely affected.

c. Remove a larger portion of the pollutional material to preserve stream quality by application of advanced waste treatment methods.

d. Provide sufficient flow to assimilate adequately treated wastes by flow regulation using storage in upstream reservoir(s).

e. Provide a combination of the above.

Current growth of the area of Tulsa served by the Bird Creek water pollution control plants will increase the pollution load on this already polluted stream which will in turn increase the extent and intensity of damages. The most reasonable long-range solution to this problem is the provision of flow regulation for water quality control and improved waste treatment. An evaluation of the need for and value of storage for water quality control purposes in multi-purpose reservoirs proposed by the Corps of Engineers on Bird Creek is contained in the Public Health Service report Storage for Municipal and Industrial Water Supply and Stream Quality Control, Sand, Copan, Birch, Candy and Skiatook Reservoirs, Lower Verdigris River Basin, Oklahoma, dated December 1961. 2/ This report is currently undergoing revision at the request of the Corps of Engineers for preparation of a General Design Memorandum preceding construction. Expectations are that the proposed Skiatook Reservoir on Hominy Creek will be in operation by 1970 or 1971 and will include quality control storage.

It is expressly stated in the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.), that storage and water releases from Federal reservoirs for the purpose of water quality control shall not be provided as a substitute for adequate treatment or other methods of controlling wastes at their source. Adequate treatment is defined as the application to the fullest extent of available technology under the particular local circumstances. In practice this means the provision of well operated secondary treatment or its equivalent. That is, the removal of dissolved and colloidal materials that in their unaltered state, as found in waste water, are not amenable to separation through the application of mechanical means and/or gravitational forces. Secondary treatment is generally accomplished through unit processes such as bio-adsorption, biological oxidation, wet combustion, other chemical reactions, adsorption on surface active media, change of phase, or other processes that result in the removal of colloidal and dissolved solids from waste waters.

Until the flow regulation program for water quality control can be placed in operation, damages to Bird Creek can be averted by either of two methods of withholding wastes (a. and b. above) or providing a high degree of treatment. Of the three possibilities, short-term provision for withholding treated wastes during low flows for release when the recovery characteristics of the stream are improved has the most merit in terms of economic feasibility and long-range usefulness. Based upon expected return flow from the population to be served by adequate treatment plants discharging to Bird Creek by 1970, approximately 2,400 acre-feet of holding capacity will be required to prevent degradation of Bird Creek during once-in-20-year low flow conditions.

These facilities would serve as an emergency holding unit in the future to insure that neither bypassed, untreated, or undertreated effluent is discharged to Bird Creek and the head of navigation.

RECOMMENDATIONS

The findings of this survey of the Arkansas River and tributaries from Tulsa to Muskogee, Oklahoma, provide the basis for recommending a four-point program for water pollution control in the survey area. This program should be implemented in the immediate future to improve existing conditions and to assure that long-range water quality management goals can be reached.

1. State and local water pollution control authroities should undertake an intensive program to assure adequate treatment and suitable disposal of wastes discharged to existing water pollution control plants. Proper operation and maintenance rank equal in importance with proper design and construction in assuring adequate treatment.

2. Secondary treatment should be provided at the City of Tulsa South Side Water Pollution Control Plant to control pollution of the Arkansas River.

3. A facility for withholding approximately 2,400 acre-feet annually of adequately treated city of Tulsa wastes from Bird Creek for up to 30 days should be provided at the earliest possible date. This effluent holding facility should be used until flow regulation for water quality control is available in this watershed.

4. A long-range pollution control plan should be developed for this reach of the Arkansas River and its tributaries considering the effects on water quality of various existing and proposed water resource developments, particularly reservoirs and navigation improvements. This plan should recognize the limited ability of the lower reaches of Bird Creek and the navigation improvements on the Verdigris River to assimilate adequately treated organic wastes. Long-range (50 to 100 years) preservation of the quality of these reaches will require planned diversion to the Arkansas River of adequately treated wastes from the Verdigris River watershed.

Further, it is recommended that additional surveys be undertaken to determine the source of the increase in BOD in the reach of the Verdigris River between the mouth of Bird Creek (river mile 63.6) and its confluence with the Arkansas River.

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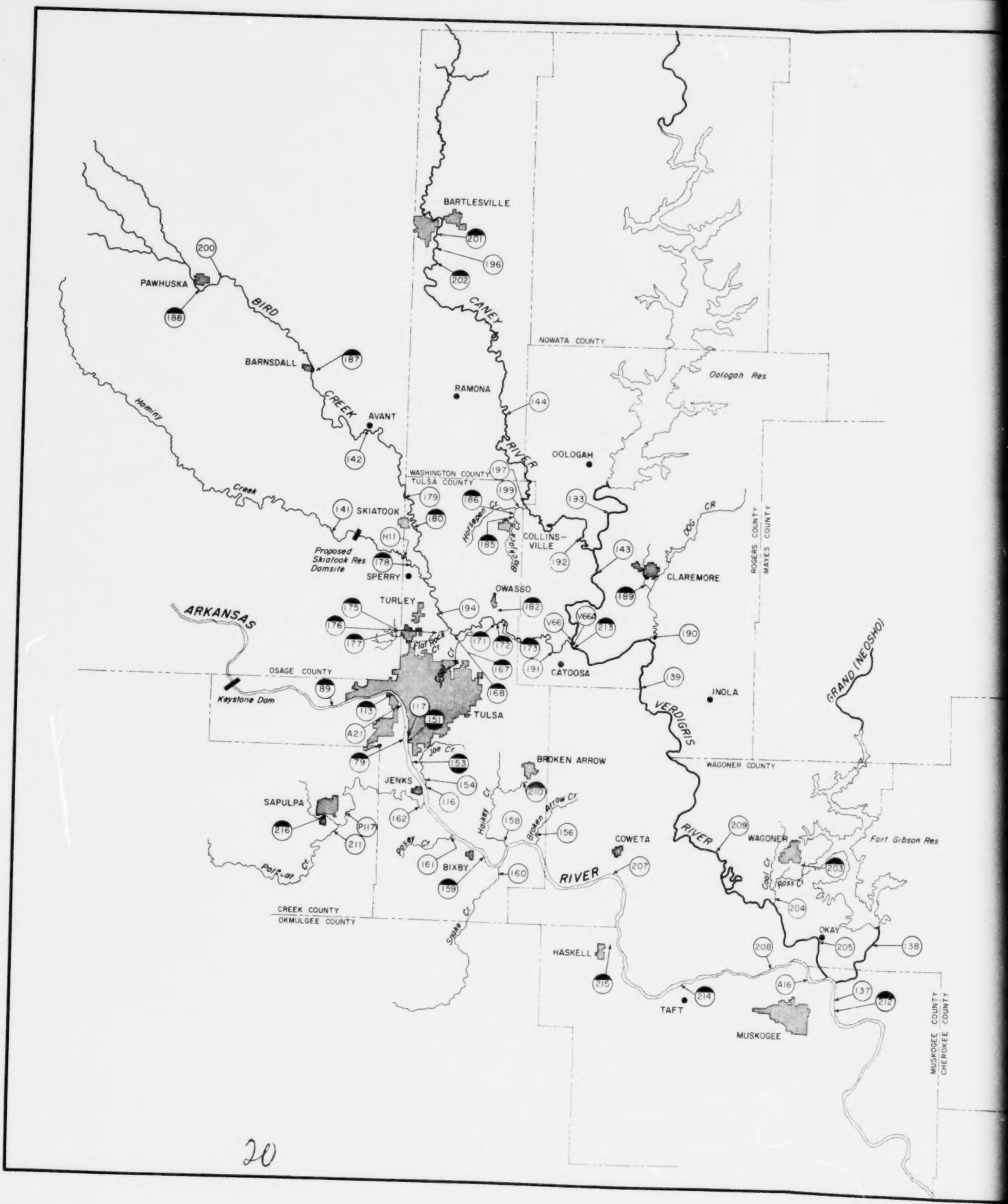
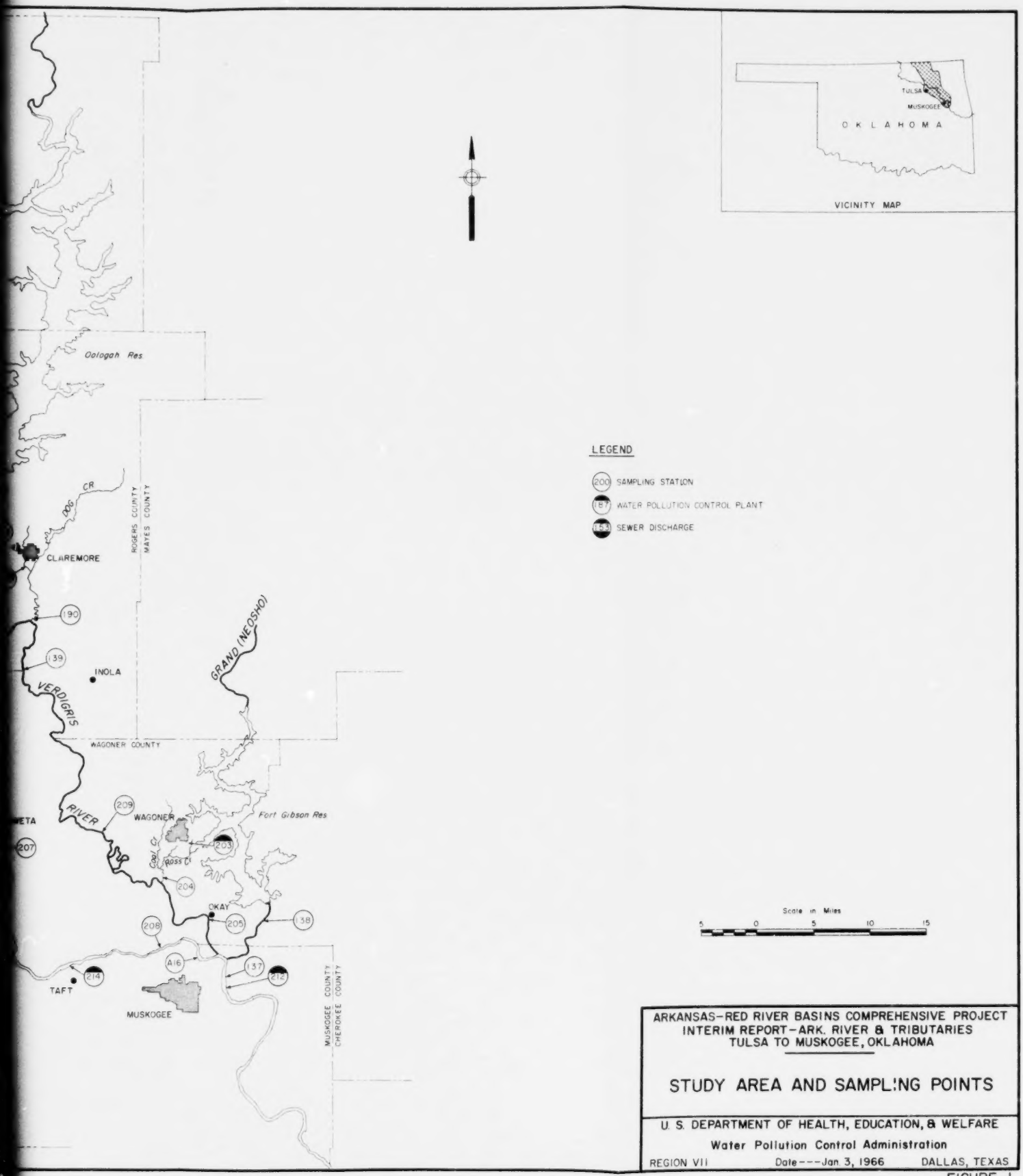

BARTLESVILLE
PAWHUSKA
BIRD CREEK
BARNSDALL
AVANT
Hominy Creek
RAMONA
CANEY RIVER
NOWATA COUNTY
Oologah Res
OOLOGAH
WASHINGTON COUNTY
TULSA COUNTY
SKIATOOK
Proposed Skiatook Res Damsite
SPERRY
Horsepen Cr.
Big Hickory Cr.
COLLINS-VILLE
Dog CR.
ROGERS COUNTY
MAYES COUNTY
CLAREMORE
OWASSO
TURLEY
ARKANSAS
Flat Rock Cr.
OSAGE COUNTY
Keystone Dam
CATOOSA
INOLA
GRAND (NEOSHO)
VERDIGRIS RIVER
TULSA
Joe Cr.
BROKEN ARROW
WAGONER COUNTY
JENKS
SAPULPA
Haikey Cr.
Broken Arrow Cr.
Posey Cr.
Polecat Cr.
BIXBY
COWETA
WAGONER
Fort Gibson Res
Cool Cr.
Ross Cr.
CREEK COUNTY
OKMULGEE COUNTY
Spring Cr.
OKAY
HASKELL
TAFT
MUSKOGEE
MUSKOGEE COUNTY
CHEROKEE COUNTY



ARKANSAS–RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT–ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

STUDY AREA AND SAMPL!NG POINTS

U. S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Water Pollution Control Administration
REGION VII Date---Jan. 3, 1966 DALLAS, TEXAS

FIGURE 1

APPENDIX "A"

DESCRIPTION OF SAMPLING POINTS

Sampling points were selected to provide as nearly as possible an indication of existing water quality. Ease of sample collection was a consideration, but every effort was made to secure samples truly representative of stream conditions. That is, a sample downstream from the confluence of two streams was assumed to represent a thoroughly mixed condition.

Table A-1 provides a brief description of each sampling point shown on Figures 1 & 7.

Sampling and Analysis Procedures

Chemical

The stream sampling program was designed to enable each stream point to be sampled at a minimum of 4 or 5 days during the survey. As far as practicable, the samples were taken such that each point was sampled on various, non-consecutive days although this was not always the case.

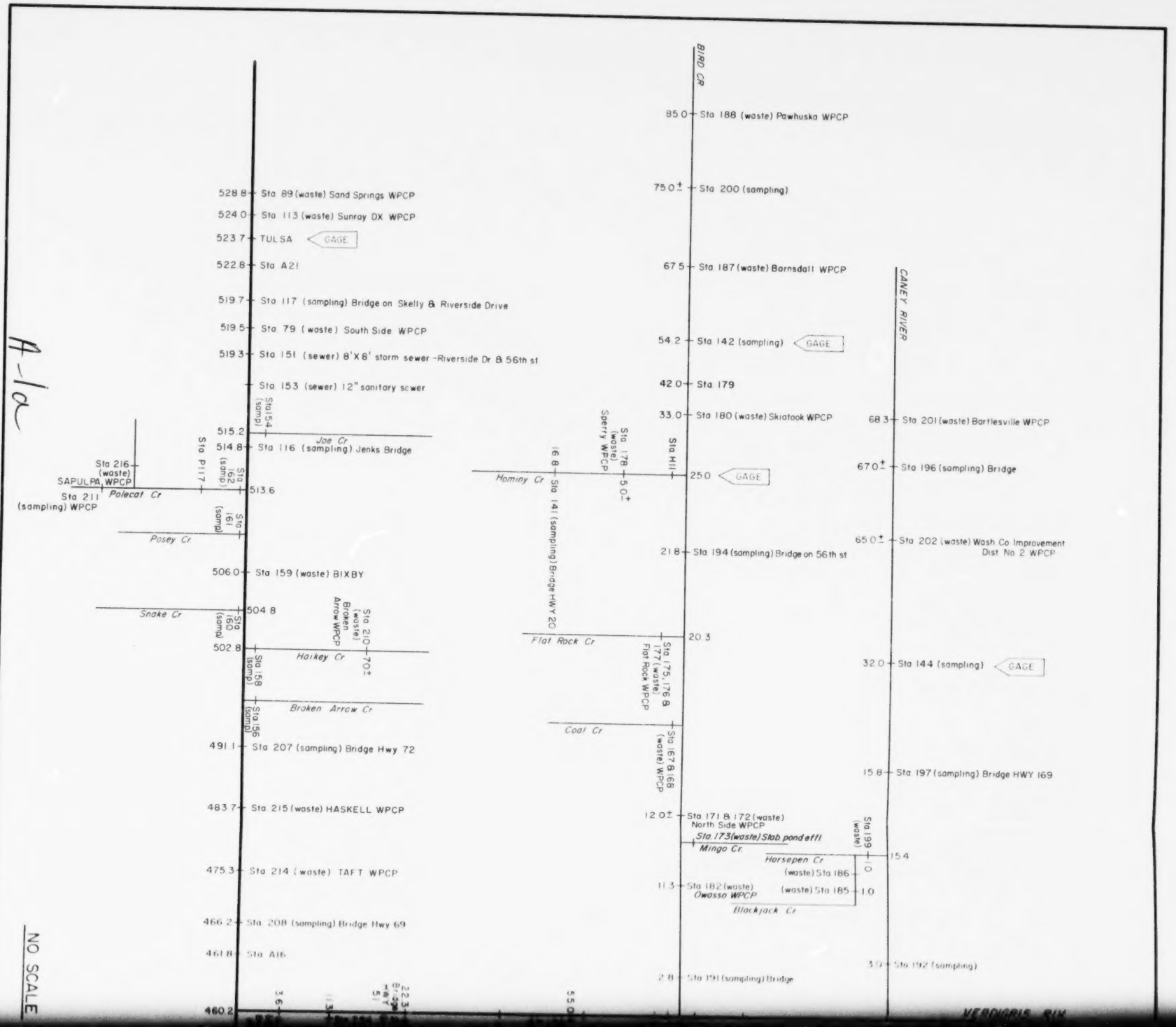
All sampling during the survey was performed from bridges if convenient and samples were taken with cans or D. O. sampler whenever possible. Each daily sample was a composite of four 1 liter samples, each taken approximately 2 hours apart. Immediately after collection, the samples were iced down for transportation to the laboratory. The field samplers ran pH, D.O., and temperature tests each time a 1 liter sample was taken.

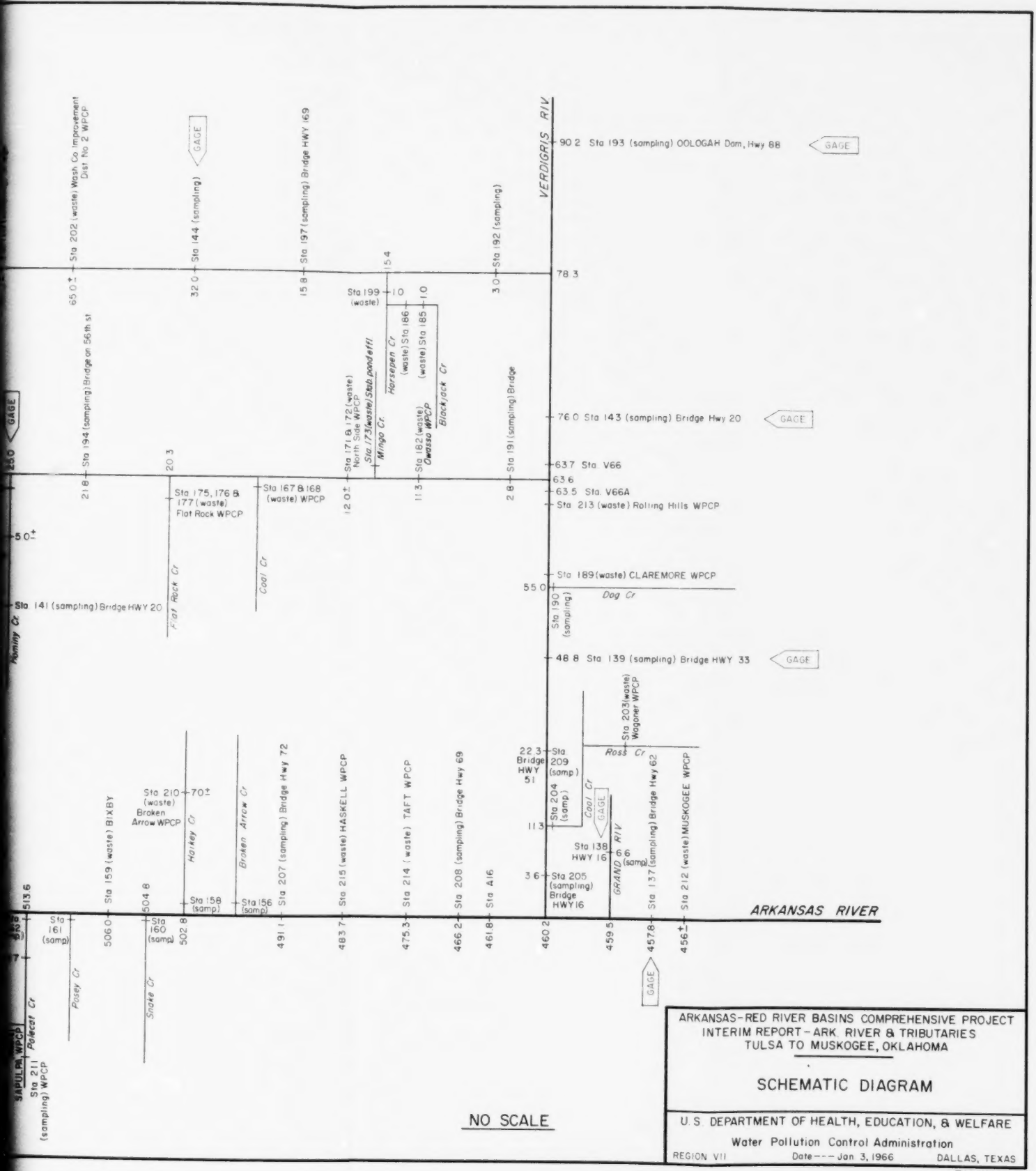
Upon completion of the 4th test in the field, the samples were taken to the laboratory generally arriving about 4:00 or 5:00 p.m.. The lab chemists set up the B.O.D's and ran tests for C.O.D. and NH_3, NO_2, and NO_3 that evening. The remainder of the tests were performed the next morning.

Bacteriological

Bacterial tests were run on 28 stations. These stations were numbered and located the same as those used for sampling for chemical tests. The study was subdivided into four sub-basins: Bird Creek, Caney River, Verdigris River, and Arkansas River.

A-1a


528.8 Sta 89 (waste) Sand Springs WPCP
524.0 Sta 113 (waste) Sunray DX WPCP
523.7 TULSA GAGE
522.8 Sta A21
519.7 Sta 117 (sampling) Bridge on Skelly & Riverside Drive
519.5 Sta 79 (waste) South Side WPCP
519.3 Sta 151 (sewer) 8'X8' storm sewer -Riverside Dr & 56th st
Sta 153 (sewer) 12" sanitary sewer
Sta 154 (samp)
515.2 Joe Cr
514.8 Sta 116 (sampling) Jenks Bridge
Sta 216 (waste) SAPULPA WPCP
Sta 211 (sampling) WPCP
Sta P117
Sta 192 (samp)
513.6
Polecat Cr
Sta 191 (samp)
Posey Cr
506.0 Sta 159 (waste) BIXBY
Snake Cr
504.8
Sta 160 (samp)
Sta 210 (waste) Broken Arrow WPCP
70±
502.8 Harkey Cr
Sta 158 (samp)
Sta 156 (samp)
Broken Arrow Cr
491.1 Sta 207 (sampling) Bridge Hwy 72
483.7 Sta 215 (waste) HASKELL WPCP
475.3 Sta 214 (waste) TAFT WPCP
466.2 Sta 208 (sampling) Bridge Hwy 69
461.8 Sta A16
460.2
BIRD CR
85.0 Sta 188 (waste) Pawhuska WPCP
75.0± Sta 200 (sampling)
67.5 Sta 187 (waste) Barnsdall WPCP
54.2 Sta 142 (sampling) GAGE
42.0 Sta 179
33.0 Sta 180 (waste) Skiatook WPCP
Sta H11
25.0 GAGE
16.8
Hominy Cr
Sta 178 (waste) Sperry WPCP
5.0±
Sta 141 (sampling) Bridge HWY 20
21.8 Sta 194 (sampling) Bridge on 56th st
20.3
Flat Rock Cr
Sta 175, 176 & 177 (waste) Flat Rock WPCP
Coal Cr
Sta 167 & 168 (waste) WPCP
12.0± Sta 171 & 172 (waste) North Side WPCP
Sta 173 (waste) Slab pond effl
Mingo Cr.
Horsepen Cr
(waste) Sta 186
(waste) Sta 185
11.3 Sta 182 (waste) Owasso WPCP
Blackjack Cr
2.8 Sta 191 (sampling) Bridge
CANEY RIVER
68.3 Sta 201 (waste) Bartlesville WPCP
67.0± Sta 196 (sampling) Bridge
65.0± Sta 202 (waste) Wash Co Improvement Dist. No 2 WPCP
32.0 Sta 144 (sampling) GAGE
15.8 Sta 197 (sampling) Bridge HWY 169
Sta 199 (waste)
15.4
1.0
1.0
3.9 Sta 192 (sampling)
VERDIGRIS RIV
NO SCALE



ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT - ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

SCHEMATIC DIAGRAM

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Water Pollution Control Administration
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FIGURE 7

Each station was sampled three times. A basin was sampled each week except for the Arkansas River Basin which required two weeks. A sterile four ounce glass water sampling bottle with a small mouth and screw cap was used. A sampler was fabricated to fit the sample bottle. It would have been much better to have a wide-mouth bottle for sampling. In situations where the stream was fairly wide, from two to four samples were taken each time. The samples were iced down in a styrofoam ice chest and transported back to the laboratory.

TABLE A-1

SAMPLING STATIONS

ARKANSAS RIVER

Station Number	Mile	Description
89	528.8	Sand Springs Water Pollution Control Plant
113	524.0	Sunray D-X Water Pollution Control Plant Effluent
A21	522.8	Arkansas River @ 21st Str. Bridge (Benthic only)
117	519.7	Arkansas River at Bridge on Skelly and Riverside Drive
79	519.5	South Side Water Pollution Control Plant Effluent - left.
151	519.3	8' x 8' Storm Sewer at Riverside Drive and 56th Street - right
153		12" Sanitary Sewer - right
116	514.8	Arkansas River at Jenks Bridge
211		Polecat Creek above Sapulpa WPCP - left
216		Sapulpa Water Pollution Control Plant - left
P117		Polecat Creek @ Highway 117 (Benthic only)
162	513.6	Mouth of Polecat Creek - left
161		Mouth of Posey Creek - left
154	515.2	Mouth of Joe Creek - right - near 91st & Lewis
159	506.0	Bixby untreated waste discharge - left
160	504.9	Mouth of Snake Creek - left
210		Broken Arrow Water Pollution Control Plant Effluent (7± miles upstream on Haikey Creek which is tributary to Arkansas River - right)

TABLE A-1 (con't)

Station Number	Mile	Description
158	502.8	Haikey Creek Mouth near 141st and 144th East Ave. South - right
156		Broken Arrow Creek near mouth - right
207	491.1	Arkansas River at Bridge south of Coweta on Highway 72
215	483.7	Haskell Water Pollution Control Plant Effluent - left
214	475.3	Taft Water Pollution Control Plant Effluent left
208	466.2	Arkansas River at Bridge north of Muskogee on Highway 69
A16	461.8	Arkansas River (Benthic only)
138	6.6	Grand Neosho River just below Ft. Gibson Dam
137	457.8	Arkansas River at Bridge East of Muskogee on Highway 62
212	456±	Muskogee Water Pollution Control Effluent to Arkansas River
		VERDIGRIS RIVER
139	48.8	Bridge west of Inola on Highway 33
143	76	Bridge west of Claremore on Highway 20
189	55.0	Claremore Water Pollution Control Plant to Verdigris
190	55.0	Dog Creek south of Claremore tributary to Verdigris
V66	63.7	Verdigris River above Bird Creek (Benthic only)
V66a	63.5	Verdigris River below Bird Creek (Benthic only)

TABLE A-1 (con't)

Station Number	Mile	Description
193	90.2	Oolagah Dam
203	11.3	Wagoner Water Pollution Control Plant on Ross Creek Tributary to Coal Creek, tributary to Verdigris southwest of Wagoner
204	11.3	Coal Creek near mouth - Tributary to Verdigris southwest of Wagoner
205	3.6	Bridge at Okay on Highway 16
209	22.3	Bridge west of Wagoner on Highway 51
		BIRD CREEK
188	85	Pawhuska Water Pollution Control Plant Effluent
200	75±	Bird Creek below Pawhuska Water Pollution Control Plant
187	67.5	Barnsdall Water Pollution Control Plant Effluent
142	54.2	Bird Creek at Avant gage
179	42.0	Bird Creek above Skiatook
180		Bird Creek at Skiatook Water Pollution Control Plant from lagoons
141	16.8	Hominy Creek at bridge on Highway 20 six miles west of Skiatook
H11		Hominy Creek (Benthic only)
178	5±	Sperry Water Pollution Control Plant Effluent to Hominy Creek
140	25	Bird Creek at Sperry gage
194	21.8	Bird Creek at Bridge on 56th Street east of Turley

TABLE A-1 (con't)

Station Number	Mile	Description
176 & 177	20.3	Flat Rock Water Pollution Control Plant Effluent
175	20.3	Flat Rock Water Pollution Control Plant Raw sewage
167 & 168	18.9	Coal Creek Water Pollution Control Plant Effluent
171	12±	North side Water Pollution Control Plant Effluent
172	12±	North side Water Pollution Control Plant Raw sewage
182	11.3	Owasso lagoons - Effluent
191	2.8	Bird Creek at bridge approximately 1½ miles northwest of Catoosa
		CANEY RIVER
201	68.3	Bartlesville Water Pollution Control Plant Effluent
196	67±	Caney River at bridge below Bartlesville Water Pollution Control Plant
202	65±	Washington County Improvement District No. 2 Water Pollution Control Plant
144	32.0	Caney River southeast of Ramona at Gage
197	15.8	Caney River at Bridge Northeast of Collinsville on Highway 169
185		Collinsville Water Pollution Control Plant Effluent to Blackjack Creek, 1 mile from mouth to Horsepen Creek to Caney River below Station 197

TABLE A-1 (con't)

Station Number	Mile	Description
186		Tulsa rendering plant wastes - Lagoons next to Station 185
199	15.4	Horsepen Creek below Station 197 and about 1 mile above mouth
192	3±	Caney River about 3 miles above mouth

Upon arrival at the laboratory, the station samples with multiple samples were composited by pouring approximately equal portions from each sample bottle into another sterile sample bottle. The samples were then placed in the refrigerator until they could be inoculated into fermentation tubes. They were generally inoculated within four or five hours of receipt in the laboratory.

Two tests for the Most Probable Number (MPN) were made. The Confirmed test for members of the coliform (Coli-aerogenes) group and the Eijkman differential test for the presence of fecal coliform (F. coli) were used. Lauryl Tryptose broth (L.S.T.) was used for the Presumptive test. Brilliant Green Lactose Bile broth (B. G. B.) was used for the Confirmed test. The Eijkman media (E.C.) was used for differentiation of fecal coliform. The incubation temperature for both the Presumptive and the Confirmed tests was 35 degrees Centigrade. The tests for fecal coliform were incubated in a water bath at 45.5 degrees Centigrade.

Four decimal portions of samples were inoculated into a series of five tubes each for each sample in the Presumptive test. Each positive Lauryl Tryptose Broth (L.S.T.) tube was inoculated into a Brilliant Green Bile broth (B.G.B.) tube and an Eijkman media (E.C.) tube. At the end of the run, the number positive B. G. B. tubes and the Positive E.C. tubes which were recorded were compared with the MPN table in "Standard Methods" and the Most Probable Number recorded according to the decimal dilution. The geometric mean of the total tests for each station was determined.

APPENDIX "B"

INDUSTRIAL WASTES PRODUCTION AND TREATMENT DATA

City	Industry	Product	Water Use MGD	Type Waste	Treated	Q. Waste MGD	Discharged To
Barnsdall	Petrolite Corp., Bareco Divn.	Wax	.720	Cooling Water	No	.144	Bird Creek
Bartlesville	National Zinc Co.	Zinc Sulphuric Acid	.543	Cooling Water	Yes	.373	Caney River
	Phillips 66	Research Lab's	.533	Cooling Water	Yes	.144	Caney River
Muskogee	Corning Glass Co.	Glassware	.295	Process Water	No	.295	Arkansas River
	Fansteel Metal-urgical Corp.	Refractory Metals	.355	Slightly Acid	Yes	.355	Arkansas River
Tulsa	Albert & Harlow Caterpillar, Inc.	Repair Tractors	.011	Soap, Oil Grease, Kerosene	No	.011	City Sanitary Sewers
	American Airlines	Repair Airplane	.685*	Industrial Sanitary	Yes No	.323 .323	Subsurface Well City Sanitary Sewers
	Automation Industries, Inc.	Aircraft & Missle Parts	.003	Caustic Soda	No	.003	City Sanitary Sewers
	Banfield Packing Company	Beef, Pork	.0033	Blood	No	.0033	City Sanitary Sewers
	Dewey Portland Cement Co.	Cememt	.516	Cooling Water	Yes	.516	Mingo Creek
	Douglas Aircraft	Repair Airplanes	.840	Toxic Metals Sanitary	Yes No	.083 .575	Mingo Creek City Sanitary Sewers

APPENDIX "B" (Con't)

City	Industry	Product	Water Use MGD	Type Waste	Treated	Q. Waste MGD	Discharged To
Tulsa	Joe S. Brown & Son Packing Co.	Beef	.0048	Blood	No	.0048	City Sanitary Sewers
	Nipak, Inc.	Fertilizer	.518	Calcium, Phopate	Yes	.040	Arkansas River
	Johnson-Fagg Engineering Co.	Oilfield Products	.008	Grease, Oil	Yes	.008	Mingo Creek
	Pure Milk	Dairy Products	.705	Dairy Waste	No	.705	City Sanitary Sewers
	Ozark-Mahoning Company	Sulphuric Acid	.030	Process Cooling	Yes	.015	Arkansas River
	Sargent Company	Aircraft Components	.003	Cooling Water	No	.003	Mingo Creek
	Sinclair Refining Company	Demulsifying Plant	.200	Cooling Water Oil, Grease	Yes	.180 .020	Arkansas River
	Sunray-DX Oil Co.	Refined Petroleum	7.50*	Phenols and Cooling Water	Yes	4.032	Arkansas River
	Texaco, Inc.	Refined Petroleum	3.53*	Phenols Cooling Water	Yes Yes	1.3 0.611	Arkansas River
	United Plating Works	Aircraft Plating	.008	Chromic Acid	No	.008	City Sanitary Sewers
Sand Springs	Pedrick Laboratories	Pet Food	.008	Process	No	.008	Arkansas River

* 1964 Yearly Use/365

APPENDIX "C"

MUNICIPAL WASTES PRODUCTION AND TREATMENT DATA

Community	Pop.	Water Use (MGD)	Water Source	Type Waste Treatment	Receiving Stream
Avant		.035	Wells	Individual Septic Tanks	Bird Creek
Barnsdall	1,663	.180	Lake	Municipal Septic Tank	Bird Creek
Bartlesville	30,000	4.5	Hulah Reservoir	Activated Sludge	Caney River
Bixby	1,711	0.13	Tulsa	None	Arkansas River
Boynton	300	.075	Reservoir	Municipal Septic tanks	Cloud Creek
Broken Arrow	9,000	.479	Wells	Trickling Filter	No Name Creek
Claremore	8,000	1.0	Dog Creek Impoundment	Trickling Filter	Dog Creek
Collinsville	2,700	.086		Biosorption	Caney River
Copan	650	.035	Wells	Lagoon	Caney River
Coweta	783	.049	Wells	Individual Septic Tanks	Arkansas River
Delaware	475	.045	Verdigris River	Lagoons	Verdigris River
Dewey	7,000	.400	Caney River	Biosorption	Caney River
Ft. Gibson	2,000	.192	Ft. Gibson	Lagoons	Grand River
Haskell	1,700	.150	Wells	Lagoons	Arkansas River
Hominy	2,900	.325	Lakes	Trickling Filter	Hominy Creek
Inola	850	.040	Lake	Lagoons	None - Evaporation
Jenks	2,000	.0996	Wells	Municipal Septic Tanks	Arkansas River

APPENDIX "C" (Con't)

Community	Pop.	Water Use (MGD)	Water Source	Type Waste Treatment	Receiving Stream
Kiefer	1,000	.055	Hayburn Lake	Lagoons	Polecat Creek
Mounds	1,000	.040	Lake	Lagoon	Snake Creek
Muskogee	13,000	6.0	Ft. Gibson Reservoir	Primary	Arkansas River
Nowata	4,500	.366	Verdigris River	Trickling Filter	Verdigris River
Owasso	3,000	.167	Spavinaw	Lagoons	Bird Creek
Pawhuska	5,000	.500	Reservoir	Trickling Filter	Bird Creek
Sand Springs	12,000	1.8	Reservoir	Trickling Filter	Arkansas River
Sapulpa	20,000	2.0	Reservoir	Trickling Filter	Polecat Creek
Skiatook	3,000	.223	Spavinaw	Lagoons	Bird Creek
Sperry	1,200	.070	Spavinaw	Trickling Filter	Hominy Creek
Taft	2,000	.170	Lake	Trickling Filter	Arkansas River
Tulsa	330,000	52.3	Spavinaw Reservoir	Primary Secondary	Arkansas River Bird Creek
Wagoner	6,000	.700	Ft. Gibson Reservoir	Trickling Filter	Arkansas River
Wynona	700	.020	Wells	Municipal Septic Tanks	Bird Creek

PREVIOUS WASTE TREATMENT AND STREAM QUALITY DATA

TABLE D-1

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1963 1964 1965	B.O.D. mg/l* 5 day	Flow MG	Flow MGD
167	Coal Creek Water Pollution Control Plant Effluent, Enters Bird Creek - Raw Sewage		18.9	1-63	201	118.9	3.8
				2-63	221	102.3	3.7
				3-63	179	119.8	3.9
				4-63	179	113.6	3.8
				5-63	176	117.8	3.8
				6-63	184	117.1	3.9
				7-63	258	96.7	3.1
				8-63	210	92.3	3.0
				9-63	-	87.9	2.9
				10-63	192	82.3	2.6
				11-63	205	75.6	2.5
				12-63	232	67.6	2.2
				Total		1191.9	
				Average	203		3.2
				1-64	224	66.8	2.2
				2-64	254	56.2	1.9
				3-64	253	70.1	2.3
				4-64	273	82.8	2.7
				5-64	-	83.4	2.7
				6-64	279	76.3	2.5
				7-64	348	71.5	2.3
				8-64	287	74.8	2.4
				9-64	226	72.3	2.4
				10-64	345	66.5	2.1
				11-64	117	92.5	3.1
				12-64	171	93.3	3.0
				Total		906.5	
				Average	252		2.4
				1-65	222	88.0	2.8
				2-65	195	78.3	2.8
				3-65	276	83.6	2.7
				4-65	204	94.2	3.1
				5-65	237	97.1	3.1
				6-65	210	84.7	2.8
				7-65	159	88.4	2.9
				Total		614.3	
				Average	219		2.8
168	Coal Creek Water Pollution Control Plant Effluent, Enters Bird Creek - Final Sewage		18.9	1-63	61	118.9	3.8
				2-63	91	102.3	3.7
				3-63	66	119.8	3.9
				4-63	70	113.6	3.8
				5-63	100	117.8	3.8
				6-63	92	117.1	3.9
				7-63	73	96.7	3.1
				8-63	101	92.3	3.0
				9-63	-	87.9	2.9
				10-63	52	82.3	2.6
				11-63	35	75.6	2.5
				12-63	109	76.6	2.2
				Total		1191.9	
				Average	77		3.2
				1-64	111	66.8	2.2
				2-64	106	56.2	1.9
				3-64	105	70.1	2.3
				4-64	78	82.8	2.7
				5-64	-	83.4	2.7
				6-64	78	76.3	2.5
				7-64	45	71.5	2.3
				8-64	51	74.8	2.4
				9-64	27	72.3	2.4
				10-64	143	66.5	2.1
				11-64	73	92.5	3.1
				12-64	49	93.3	3.0
				Total		906.5	
				Average	78		2.4
				1-65	79	88.0	2.8
				2-65	110	78.3	2.8
				3-65	77	83.6	2.7
				4-65	65	94.2	3.1
				5-65	72	97.1	3.1
				6-65	53	84.7	2.8
				7-65	65	88.4	2.9
				Total		614.3	
				Average	74		2.8

Station No.	Location	Stream	Mile	Date 1963 1964 1965	B.O.D. mg/l* 5 day	Flow MG	Flow MGD
175	Flat Rock Water Pollution Control Plant - Raw Sewage		20.3	1-63	222	102.6	3.3
				2-63	279	82.5	3.0
				3-63	188	183.3	6.5
				4-63	236	103.9	3.5
				5-63	157	105.3	3.4
				6-63	191	93.5	3.1
				7-63	167	123.9	4.2
				8-63	154	118.3	3.8
				9-63	157	108.0	3.6
				10-63	170	115.4	3.7
				11-63	173	116.3	3.9
				12-63	183	123.0	4.0
				Total		1376.4	
				Average	189		3.7
				1-64	189	123.1	4.0
				2-64	209	118.5	4.1
				3-64	211	77.3	3.8
				4-64	192	111.2	4.4
				5-64	164	137.0	4.4
				6-64	163	119.3	4.0
				7-64	131	93.5	3.0
				8-64	145	102.2	3.3
				9-64	170	114.3	3.8
				10-64	154	113.9	3.7
				11-64	162	136.0	4.5
				12-64	191	127.3	4.1
				Total		1373.6	
				Average	143		3.7
				1-65	146	134.7	4.3
				2-65	191	115.3	4.1
				3-65	189	132.1	4.3
				4-65	144	133.4	4.8
				5-65	138	139.8	4.5
				6-65	187	139.7	4.7
				7-65	112	145.7	4.7
				Total		940.7	
				Average	158		4.4
176	Flat Rock Water Pollution Control Plant Effluent Final Sewage		20.3	1-63	125	102.6	3.3
				2-63	86	82.9	3.0
				3-63	75	183.3	6.5
				4-63	131	103.9	3.5
				5-63	59	105.3	3.4
				6-63	80	93.5	3.1
				7-63	93	123.9	4.2
				8-63	63	116.3	3.8
				9-63	47	108.0	3.6
				10-63	29	115.4	3.7
				11-63	45	116.3	3.9
				12-63	53	123.0	4.0
				Total		1376.4	
				Average	73		3.7
				1-64	176	123.1	4.0
				2-64	138	118.5	4.1
				3-64	139	77.3	3.8
				4-64	154	111.2	4.4
				5-64	81	137.0	4.4
				6-64	44	119.3	4.0
				7-64	47	93.5	3.0
				8-64	54	102.2	3.3
				9-64	53	114.3	3.8
				10-64	40	113.9	3.7
				11-64	53	136.0	4.5
				12-64	57	127.3	4.1
				Total		1373.6	
				Average	86		3.7
				1-65	95	134.7	4.3
				2-65	71	115.3	4.1
				3-65	76	132.1	4.3
				4-65	51	133.4	4.8
				5-65	65	139.8	4.8
				6-65	67	139.7	4.7
				7-65	75	145.7	4.7
				Total		940.7	
				Average	71		4.4

* Monthly average

Construction period for additions and revisions: Aug 1963 - Sept 1964.

Source: City of Tulsa, Water and Sewer Department

TABLE D-2

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1963	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
171	North Side Water Pollution Control Plant Effluent, Bird Creek Sampling Station		12±	1-1	57	4.8				2.6
				2	57	4.2				2.7
				3	56	5.0				2.7
				4	56	6.0				4.0
				5	58	4.6				5.3
				6	55	5.6				2.7
				7	56	5.2		7.5		3.9
				8	56			7.6		3.5
				9	58	5.4	24			3.5
				10	56	5.2		7.7		2.3
				11	50	5.4	20	7.8		2.7
				19	56	5.6	24	7.7		3.5
		Composites		16	50	6.4	2.	7.7		3.2
				12	38	10.2				3.0
				13	34	10.8				3.0
				14	46			7.6		3.3
				15	50	6.4		7.6		3.1
				16	51	6.6	21	7.7		3.2
				17	52	6.6		7.7		3.3
				18	52	6.6	20	7.7		3.3
				19	44	7.4				3.1
				20	40	9.2		7.8		3.0
				21	51	7.4		7.7		3.6
				22	52	6.4		7.7		3.5
				23	52	6.4	19	7.7		3.1
				24	38	9.8		7.7		3.4
				25	38	9.8	21	7.7		3.4
				26	46	7.2		7.7		3.4
				27	44	7.6		7.7		2.8
				28	44	6.8		7.7		3.5
				29	47	8.2		7.7		2.8
				30	47	8.2	24	7.7		2.9
				31	52	7.0		7.7		3.0
				2-1	52	7.0	20	7.6		3.0
				2	52	4.8				3.0
				3	50	6.6		7.7		2.7
				4	50	6.4				3.4
				8	52	4.8	18	7.8		2.8
				9	52	6.0		7.6		2.8
				10	52	4.4		7.6		2.6
				11	52	7.4		7.7		2.7
				12	46	6.2		7.7		2.7
				13	46	8.2	21	7.7		2.9
				14	50	6.2		7.6		2.6
				15	50	6.2		7.7		2.8
				16	52	6.2		7.7		2.9
				17	53	5.2		7.4		2.2
				18	54	5.6		7.6		3.2
				19	54	6.2		7.6		2.9
				20	54	4.8	22	7.6		2.7
				21	47	6.8		7.7		2.6
				22	47	6.8	19	7.8		2.7
				23	49	7.0		7.8		2.7
				24	50	5.8		7.5		2.3
				25	53	5.6		7.7		3.0
				26	52	4.4		7.7		3.4
				27	56	4.6		7.8		3.1
				28	50	4.4		7.8		2.5
				3-1	50	4.8	12	7.8		2.9
				2				7.5		0.9
				3	55	5.4				2.3
				4	59	5.8		7.6		1.7
				5	50	7.2				3.1
				6	52	6.2	16	7.8		4.7
				7	56	7.2		7.7		4.0
				8	56	7.2	12	7.7		3.7
				9	56	7.2		7.9		3.4
				10	55	6.4		7.7		3.3
				11	56	7.0		7.8		5.4
				12	58	6.4		7.6		4.2
				13	58	6.4	18	7.8		3.5
				14	55	7.6		7.7		4.6
				15	55	7.6	14	7.6		3.4
				16	59	6.8		7.9		3.5
				17	58	5.8				3.1
				18	59	6.2		7.5		3.7
				19	60	4.6		7.6		3.9
				20	60	4.6	20	7.7		3.8
				21	58	4.6		7.6		3.6
				22	59	3.2				3.6
				23	61	1.4		7.6		3.3
				24	62	4.8		7.6		2.8
				25	64	4.0		7.6		3.8
				26	63	3.4		7.7		3.4
				27	63	5.4	21	7.8		3.6
				28	63	5.6		7		3.6
				29	63	5.6	20			3.1
				30	68	3.6				2.7
				31	69	4.2		7.7		3.1
				4-1	66	4.6		7.7		2.7
				2	66	5.6		7.7		3.5
				3	66	5.6	15	7.7		3.4
				4	61	5.2		7.7		3.4
				5	61	5.2	17	7.8		3.4
				6	63	4.6		7.7		3.5
				7	62	4.8		7.5		3.2
				8	66	5.0		7.8		4.0
				9	68	4.8		7.5		3.7
				10	68	4.8	14	7.8		3.5
				11	63	1.4		7.7		3.4
				12	63	1.4	21	7.9		3.5
				13	64	3.6		7.6		3.4
				14	65	3.2		7.6		2.9
				15	65	3.6		7.6		4.0
				16	71	4.4		7.7		3.7
				17	71	4.4	19	7.9		3.6
				18	69	4.8		7.9		3.8
				19	69	3.2				3.9
				20	67	4.6		7.7		3.6
				21	71	4.8		7.9		3.3
				22	70	5.0		7.7		4.0
				23	66	3.4		7.7		3.3
				24	66	3.4	15	7.7		3.5
				25	By-Pass					2.8
				26	65	4.0				5.0
				27	65	6.4		7.7		4.7
				28	63	5.3		5.2		3.8
				29	68	5.0		7.7		4.3
				30	64	4.6		7.7		3.6
				5-1	64	4.6	12	7.7		3.7
				2	64	5.0		7.8		3.5
				3	61	5.0	14	7.8		3.6
				4	71	5.2		7.6		3.7
				5	72	2.6		7.7		3.1
				6	72	4.2		7.6		3.9
				7	71	4.8		7.7		3.4
				8	71	4.8		7.6		3.7
				9	72	4.6		7.7		2.7
				10	76	4.6	12	8.0		2.0
				11	74	3.6		7.7		3.7
				12	75	1.8		7.7		3.0
				13	72	4.6		8.0		4.0
				14	74	4.2		7.6		4.8
				15	74	4.2	10	7.8		3.7
				16	76	2.6		7.7		3.9
				17	76	2.6	8	8.0	68	3.3
				18	74	3.0		7.9		3.9
				19	74	2.0		7.6		3.3
				20	70	3.8		7.6		4.0
				21	70	1.0		7.7		3.6
				22	70	1.0	14	7.6		3.4
				23	64	1.8		7.6		3.7
				24	64	1.8	18	7.8		3.5
				25	73	2.8		7.6		4.2
				26				7.7		2.2
				27	72	4.0		7.5		4.5
				28	74	0.4		7.5		3.4
				29	74	0.4	16	7.6		3.3
				30	76	0.1		7.3		3.7
				31	76	0.1	12	7.4		3.0
				6-1	71	1.8		7.5		2.7
				2	75	4.0		7.5		3.0
				3	75	4.4		7.5		3.7
				4	77	3.6		7.5		3.1
				5	77	3.6	11	7.7	64	3.2
				6	78	4.6		7.5		3.4
				7	78	4.6	11	7.7		
				8	77	3.0		7.6		3.2
				9	78	1.6		7.4		3.1
				10	78	3.6		7.3		4.1
				11	78	3.6		7.4		3.4
				12	78	3.8	18	7.5	66	3.6
				13	79	3.0		7.6		3.8
				14	79	3.0	10	7.6		3.6
				15	78	1.6		7.4		3.7
				16	75	1.0		7.5		3.3
				17	75	4.6		7.4		3.2
				18	76	2.8		7.4		3.6
				19	78	3.4		7.3		3.5
				20	77	0.6		7.4		3.5
				21	78	4.2		7.4		3.8
				22	77	0.6		7.4		11.1
				23	77	0.8		7.4		
				24	79	4.4				3.7
				25	79	4.0		7.4		3.5
				26	79	3.6		7.5		4.4
				27	79	4.4				3.0
				28	80	4.2				2.9
				29	79	1.4		7.5		3.9
				30	81	1.2		7.5		3.4

Source: City of Tulsa, Water & Sewer Department

TABLE D-2 (Con't)

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1963	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
171	North Side WPCP Effluent, Bird Creek Sampling Sta. (Con't)		12+	7-1	81	2.4		7.5		4.0
				2	81	4.4		7.5		3.1
				3	81	4.8		7.5		2.8
				4	82	2.8				3.4
				5	81	5.4				3.6
				6	80	4.0		7.6		3.2
				7	81	2.2		7.3		2.9
				8	81	4.6		7.5		3.7
				9	81	4.8		7.5		4.1
				10	78	4.8	9	7.6		4.2
				11	74	3.2		7.5		7.0
				12	74	3.2	9	7.5		5.1
				13	80	5.2				3.9
				14	80	5.2				3.6
				15	79	5.2		7.6		3.9
				16	81	4.4		7.5		4.2
				17	81	4.4	8	7.8		3.8
				18	81	4.6		7.6		3.8
				19	81	3.6		7.6		3.8
				20	82	2.0		7.8		3.8
				21	83	1.6		7.9		3.3
				22	83	2.4		7.6		4.1
				23	83	4.6		7.4		3.8
				24	83	4.6	8	7.7		4.0
				25	83	4.6		7.5		3.6
				26	83	4.6	8	7.7		3.2
				27				7.6		2.0
				29	81	5.0				2.5
				30	80	6.0		7.5		3.5
				31	80	6.0	9	7.8		4.5
				8-1	84	5.0		7.6		4.4
				2	84	5.0	7	7.3		4.3
				3	81	4.0		7.7		4.2
				4	82	5.4		7.6		3.5
				5	81	5.2		7.5		4.2
				6	83	4.0		7.5		3.9
				7	80	2.6		7.7		3.8
				8	84	3.8		7.4		4.0
				9	84	3.8	10	7.6		3.7
				10	83	4.6		7.5		3.9
				11	86	1.8		7.5		3.3
				12	83	3.4		7.5		4.0
				13	81	2.4		7.6		3.7
				14	81	2.4	9	7.7		3.6
				15	79	5.0		7.5		3.6
				16	79	5.0	10	7.6		3.7
				17	79	3.0		7.3		3.5
				18	80	2.8		7.4		3.2
				19	78	5.0		7.3		3.7
				20	78	4.6		7.4		3.6
				21	79	1.8	7	7.6		3.4
				22	80	3.2		7.6		3.4
				23	81	5.4	9	7.5		3.6
				24	82	1.8		7.6		3.4
				25	82	2.4				2.9
				26	83	3.8		7.6		4.0
				27	84	2.0		7.6		3.5
				28	83	2.2		7.5		3.5
				29	80	2.2		7.5		3.2
				30	81	4.6		7.8		3.8
				31	81	1.4		7.6		3.2
				9-1	79	1.8		7.6		2.8
				2	78	2.4		7.5		3.7
				3	82	4.0		7.7		3.8
				4	81	4.2	9	7.7		4.8
				5	79	3.0				4.0
				6	82	4.8	9			4.6
				7	80	3.0		7.3		4.4
				8	82	2.4		7.4		3.8
				9	82	4.8		7.3		4.8
				10	82	1.0		7.4		4.3
				11	82	1.0	10	7.9		4.0
				12	81	3.6		7.4		3.8
				13	76	2.8		7.5		3.8
				14	75	2.8		7.5		3.7
				15	77	2.8		7.6		3.6
				16	81	4.6		7.2		4.3
				17	79	5.0		7.5		3.9
				18	78	4.0		7.7		3.8
				19	80	4.6				3.8
				20	80	2.0				3.8
				21	80	1.4		7.5		4.0
				22	80	1.6		7.3		4.3
				23	79	3.0		7.5		3.5
				24	77	1.8		7.4		3.8
				25	77	2.6		7.4		4.0
				26	76	4.8				4.3
				27	76	2.6				4.2
				28	77	2.4		7.4		4.3
				29	72	3.2		7.5		3.8
				30	70	4.8		7.4		4.2

Date 1963	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
10-1	73	2.8		7.3		4.1
2	74	3.2		7.5		4.2
3	75	4.8				4.1
4	73	2.2				4.2
5	78	2.2		7.4		3.2
6	77	2.4		7.6		3.7
7	75	2.4		7.5		4.5
8	76	1.8		7.3		4.2
9	78	2.4		7.5		4.0
10	75	2.2		7.4		4.4
11	75	1.8		7.4		4.3
12	75	2.8		7.5		4.4
13	76	2.6		7.3		3.9
14	76	2.8		7.4		4.7
15	76	4.8		7.4		4.5
16	76	4.8	10	7.6		4.2
17	75	4.4		7.4		4.2
18	76	5.0		7.5		4.3
19	75	2.4		7.6		4.3
20	75	2.8		7.5		3.7
21	74	4.1	11	7.0		4.4
22	74	3.8				4.4
23	74	3.3				3.8
24	73	3.6		7.6		3.5
25	74	3.5		7.6		3.8
26	75	3.6		7.5		3.7
27	76	3.9		7.5		3.3
28	69	4.6		7.5		4.0
29	60	5.1		7.5		3.5
30	65	4.8		7.7		3.5
31	68	4.4	10	7.5		3.5
11-1	63	4.6	10	7.6		3.7
2	63	5.0		7.6		3.7
3	63	5.1		7.5		3.4
4	66	4.5	13	7.7		4.3
5	63	2.8		7.6		3.8
6	67	3.4	12	7.5		3.9
7	66	3.7	15	7.4		4.0
8	67	3.9	12	7.4		4.2
9	67	3.8		7.4		5.2
10	67	3.8		7.2		4.5
11	76	4.3	10	7.3		4.0
12	64	4.5		7.3		6.6
13	64	3.4		7.5		2.9
14	58	5.3	11	7.5		3.0
15	59	3.3	11	7.4		3.1
16	64	3.4		7.4		3.2
17	65	4.6		7.4		2.8
18	62	4.9				3.7
19	61	4.9		7.2		3.9
20	62	4.9		7.6		5.2
21	62	4.9		7.4		3.4
22	64	4.4		7.3		3.6
23	56	5.6		7.3		3.5
24	57	6.0		7.3		2.9
25	56	5.7		7.3		3.5
26	55	5.5		7.4		3.4
27	55	5.6		7.3		3.0
28	55	5.2		7.4		2.9
29	51	6.2		7.3		3.1
30	52	5.9		7.4		3.1
12-1	53	6.2		7.4		3.0
2	51	6.2	13	7.4		3.6
3	50	5.9		7.3		3.3
4	51	5.8	18	7.4		3.1
5	52	5.6		7.4		3.2
6	52	5.2		7.3		3.1
7	53	4.9		7.3		3.3
8	52	6.2		7.2		3.0
9	42	6.6		7.8		3.3
10	47	6.5		7.8		3.0
11	42	7.0		7.6		2.9
12	39	7.4		7.2		2.9
13	40	7.3		7.2		2.7
14	39	7.0		7.0		2.8
15	39	6.8		6.8		2.6
16	41	6.6	23	7.3		3.1
17	41	6.3		7.3		2.8
18	42	7.5	16	7.2		3.0
19	36	7.2		7.2		3.1
20	36	7.3		7.0		3.2
21	34	8.1		7.2		3.0
22	32	8.5		7.3		2.8
23	32	8.2		7.2		3.3
24	35	7.0		7.7		3.4
25	42	5.8		7.6		3.0
26	42	5.1		7.4		3.5
27	42	4.8		7.6		3.3
28	41	5.3		7.8		3.2
29	39	5.6				2.5
30	36	6.2		7.7		2.2
31	38	5.8		7.5		3.0

TABLE D-2 (Con't)

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1964	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl^- mg/l	Flow MGD
171	North Side WPCP Effluent Bird Creek Sampling Sta. (Con't)		12±	1-1	38	5.9		7.3		2.7
				2	46	5.5		7.4		3.2
				3	55	5.4		7.3		3.1
				4	52	5.5		7.8		3.0
				5	51	6.0		7.5		2.6
				6	53	4.9	20	7.5		4.0
				7	55	2.6		7.5		4.4
				8	55	3.3	35	7.9		4.0
				9	49	6.0		7.3		3.8
				10	49	6.8		7.3		3.8
				11	50	7.0		8.1		3.8
				12	49	8.4		7.8		3.3
				13	36	8.7	23	7.8		4.0
				14	43	8.0		7.5		3.8
				15	47	7.2		7.7		3.6
				16	49	6.4		7.6		3.8
				17	51	6.7	18	7.3		3.8
				18	51	6.0				3.8
				19	55	5.9				3.8
				20	53	6.1	16	7.6		4.0
				21	56	5.4		7.3		3.2
				22	56	4.6	21	7.6	64	3.5
				23	59	4.7	18	7.4	64	3.9
				24	58	5.3	18	7.8	70	3.2
				25	52	6.8				2.9
				26	53	6.0				2.4
				27	54	6.0	16	7.7		3.1
				28	51	6.1		7.6		2.8
				29	52	6.1	17	7.6	76	2.7
				30	53	5.5		7.4		3.0
				31	56	5.3		7.4		3.2
				2-1	53	5.4		7.3		3.2
				2	56	5.3		7.7		2.6
				3	53		15	7.6		3.3
				4						3.0
				5	55	5.6	13	7.0	74	6.5
				10	56	6.2	12	7.5		3.5
				11		6.3		7.2		3.4
				12	52	6.6	14	7.4		3.1
				13	52	6.2		7.5		3.0
				14	53	6.6		7.5		3.1
				15		6.4		7.4		3.2
				16	51	6.0		7.5		3.4
				17	53	6.2	12	7.3	74	3.9
				18	54	5.9		7.4		3.8
				19	52	6.4	15	7.7	66	3.5
				20	52	6.5		7.5		3.1
				21	49	6.7		7.3		3.2
				22	49	6.7		7.5		3.2
				23		6.5		7.0		3.5
				24	50	6.0		7.6		4.0
				25	53	6.0		7.1		3.8
				26	53	6.0	12	7.4		3.6
				27	51	6.4		7.6		3.1
				28	52	6.2		7.1		3.3
				29	52	6.2		7.7		3.2
				3-1	53	6.0		7.4		3.4
				2	57	5.1	10	7.4		3.9
				3	53	4.7		7.1		3.9
				4	53	5.7	8	7.2		3.1
				5	52	6.3		7.1		4.9
				6	56	6.0		7.1		4.1
				7	56	6.2		7.4		3.9
				8	53	6.0		7.1		3.9
				9	52	6.7	16	7.1	64	9.3
				10	52	6.4		7.7		7.1
				11	54	6.3	18	7.2		5.6
				12	55	6.1		7.0		4.3
				13	56	5.8		7.4		4.2
				14	60	6.0		7.2		4.0
				15	56	6.0				4.1
				16	58	5.6				4.3
				17	60	5.5		7.4		4.0
				18	59	5.4				3.9
				19	57	5.3				5.4
				20	54	6.2		7.7		4.9
				21	51	6.7		7.8		4.4
				22	50	6.2		7.4		3.2
				23	60	5.8		7.6		4.7
				24	62	5.1		8.0		4.0
				25	52	6.0		7.4		3.9
				26	50	6.6		7.4		3.8
				27	55	6.4		7.2		3.8
				28	55	5.8		7.2		2.2
				29	55	6.0		7.1		3.4
				30	52	6.5		7.2		4.1
				31	55	5.6		7.1		4.2

Date 1965	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl^- mg/l	Flow MGD
4-1	63	4.9	19	7.2		3.9
2	65	4.8		7.2		3.9
3	65	4.1		7.1		3.8
4	62	4.7		7.2		7.8
5	-	-		7.0		1.1
6 & 7	By Pass					
8	55	6.8				5.3
9	58	6.0		6.9		4.8
10	61	5.5		7.1		4.6
11	60	6.1		7.0		4.1
12	63	5.6		6.9		4.5
13	61	5.5	16	7.3		4.9
14	62	5.2				4.7
15	63	5.3	17	7.3		4.4
16	65	5.1		7.2		4.4
17	65	4.8		6.9		4.0
18	69	4.5		7.2		4.1
19	71	4.3		7.2		3.8
20	70	4.0	13	7.0		5.3
21	69	3.2				4.9
22	69	3.7	20	7.0		4.3
23	70	3.6		6.9		4.2
24	71	3.6		6.8		4.1
25	71	3.8		6.3		4.1
26	68	3.9		6.4		4.0
27	67	4.2	18	7.2		4.4
28	63	4.6		7.2		4.4
29	65	3.8		7.2		3.9
30	67	3.4		7.0		3.7
5-1	68	3.9		6.7		3.7
2	70	4.0		7.1		4.4
3	66	3.9		6.4		3.9
4	72	3.1	16	6.8		4.3
5	71	3.1		5.6		4.2
6	71	3.1	18	7.1		4.6
7	72	3.5		6.5		3.9
8	72	3.5		7.0		4.2
9	73	3.2		6.2		3.8
10	73	2.9		6.1		4.7
11	67	3.5	15	6.3		6.2
12	66	4.9		6.4		5.6
13	67	4.3	15	6.1		5.3
14	68	4.3		5.7		4.5
15	70	4.0		7.6		4.3
16	73	3.0		7.7		4.3
17	76	3.2		7.4		4.2
18	75	2.5	13	7.5		4.6
19	75	3.8		7.3		4.3
20	75	3.3	14	7.5	70	4.3
21	76	2.6		7.6		3.9
22	76	2.9		7.6		4.0
23	77	2.9		7.5		3.9
24	75	3.3		7.6		5.3
25	72	2.6	14	7.7		4.3
26	79	1.8		7.5		4.5
27	80	2.3	18	7.5		4.3
28	71	3.6		7.6		3.6
29	70	3.6		7.6		3.4
30	68	3.8		7.5		3.2
31	69	4.0		7.5		3.4
6-1	69	3.4	11	7.6		4.2
2	68	4.0		7.4		4.1
3	71	3.0	13	7.6	72	3.2
4	73	3.1		7.5		2.3
5	73	2.5		7.6		3.9
6	75	2.4		7.4		3.8
7	75	3.4		6.8		3.3
8	77	3.1		7.4		4.2
9	77	2.8		7.4		3.9
10	81	1.8	12	7.1		3.9
11	86	2.2		7.4		3.8
12	79	3.1		7.1		3.6
13	81	2.4		7.2		3.8
14	82	2.6		7.0		3.7
15	78	3.3	16	6.9		4.5
16	80	2.0		7.3		4.7
17	80	2.0	19	7.4	78	4.6
18	80	2.2				4.6
19	76	1.9		7.4		4.1
20	83	2.1		7.4		3.8
21	84	1.5		7.3		3.6
22	81	1.5	12	7.4		4.2
23	77	2.1		7.3		4.6
24	79	1.2	16	7.1	76	4.2
25	77	1.2		7.2		3.9
26	79	1.0				3.8
27		1.1		7.2		3.6
28	85	1.8		7.2		4.4
29			14	7.7		4.0
30	79					4.2

TABLE D-2 (Con't)

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1964	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
171	North Side WPCP Effluent, Bird Creek Sampling Sta. (Con't)		12±	7-1	79	2.0	12	7.5		4.3
				2	81	1.6		7.2		4.0
				3	81	1.6		7.2		3.7
				4	84	2.1		7.3		3.2
				5	86	3.4		7.1		3.5
				6	80	1.8	7	7.7		4.2
				7	81	1.5		7.3		3.7
				8	83	2.0	12	7.8	76	3.4
				9	83	1.0		7.2		3.8
				10	81	1.8		7.3		3.7
				11	83	2.3		7.2		3.6
				12	79	3.2		7.1		3.5
				13	77	2.7	9	7.7		4.2
				14	79	2.1		7.6		4.0
				15	79	2.1	11	7.6	74	3.8
				16	81	2.2		7.6		3.6
				17	83	2.1		-		3.4
				18	84	2.1		7.5		3.9
				19	84	2.1		7.2		3.6
				20	84	1.8	9	7.3		4.2
				21	84	1.5		7.2		4.3
				22	84	1.8	10	7.4	74.5	4.2
				23	82	1.5		7.4		3.0
				24	82	1.9		7.1		4.9
				25	82	1.8		7.4		4.6
				26	81	1.6		7.3		3.7
				27	81	2.0	bypass			4.2
				28	82	2.1		7.4		4.5
				29	83	2.3	8	7.2		4.2
				30	84	2.1		7.4		4.2
				31	83	2.1		7.4		4.2
				8-1	84	2.2		7.2		4.0
				2	84	2.7		7.4		3.9
				3	83	2.3		7.3		4.5
				4	83	1.7		7.3		4.5
				5	83	2.3	9	7.4	75	4.0
				6	83	2.7		7.4		3.9
				7	82	2.6		7.3		3.9
				8	82	2.6		7.5		3.7
				9	82	2.8		7.3		3.7
				10	79	3.0	5	7.6		4.7
				11	80	2.5		7.4		4.6
				12	76	3.1	8	7.6		4.2
				13	75	2.6		7.4		4.1
				14	73	2.7	10	7.5		4.4
				15	64			7.4		3.1
				16	75	3.2		7.6		3.5
				17	78	3.0	10	7.6		4.4
				18	80	1.9		7.5		4.3
				19	82	2.0		7.4		4.8
				20	82	2.3		7.7		3.6
				21	79	2.2		7.7		3.5
				22	80	2.5		7.5		3.4
				23	79	3.1		7.3		2.8
				24	80	2.9		7.5		4.1
				25	78	2.6		7.5		4.1
				26	76	2.8	10	7.5		3.7
				27	77	3.2		7.5		4.2
				28			12	7.7		3.2
				29	80	3.6				4.2
				30				7.6		3.7
				31	82	3.1				6.0
				9-1	82	3.0		7.6		4.8
				2	82	2.3	9	7.6	64.7	4.2
				3	82	2.6		7.6		4.4
				4	83	2.5	9	7.6		4.2
				5	83	1.8		7.4		3.8
				6	82	3.4		7.3		3.6
				7	82	3.2		7.4		4.1
				8	80	2.2		7.5		4.3
				9	81	2.1	11	7.5		4.9
				10	82	2.2		7.4		4.5
				11	77	3.2	10	7.6		3.9
				12	74	3.3		7.8		4.0
				13	73	3.6		7.5		3.5
				14	75	3.2		7.3		4.4
				15	74	2.8		7.5		3.7
				16	72	3.1	9	7.3		3.7
				17	74	2.8		7.3		3.7
				18	76	2.2		7.6		3.9
				19	79	2.5		7.4		3.8
				20	77	3.3		7.4		3.9
				21	72	3.1	7	7.3		4.7
				22	76			7.4		3.9
				23	76	3.3				3.9
				24	75	3.2		7.5		4.3
				25	76	3.8	7	7.5		3.8
				26	74	3.6		7.6		3.6
				27	73	4.3		7.6		3.8
				28		4.3	8	7.4		4.2
				29	73	3.8		7.3		3.6
				30	72	3.9	6	7.4		4.3

Date 1964	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
10-1	72	3.7		7.5		4.6
2	71	3.4	11	7.6		4.0
3	72	3.4		7.5		3.8
4	71	4.2		7.4		4.0
5	70	4.5	8	7.6		3.1
6	67	4.1		7.6		4.3
7	68	3.8	8	7.6		4.5
8	67	4.1		7.5		4.0
9	65	4.1		7.6		3.9
10	66	4.2		7.5		3.8
11	65	4.2		7.5		4.1
12	65	4.0	10	7.6		5.2
13	67	3.6		7.3		4.8
14	70	3.3		7.6		4.4
15	70	3.5		7.3		3.7
16	70	3.5		7.3		3.8
17	73	3.4		7.3		4.1
18	68	3.9				3.4
19	64	4.7		7.6		4.3
20	64	4.1		7.6		3.7
21	66	3.7		7.5		3.7
22	66	3.5		7.4		3.9
23	67	3.8		7.3		4.1
24	67	3.8		7.3		3.7
25	66	4.7		7.3		3.3
26	66	4.7		7.3		3.3
27	69	3.3		7.3		4.1
28	71	3.2		7.3		4.1
29	71	3.3		7.5		4.4
30	70	3.3		7.4		4.2
31	73	3.3		7.4		3.9
11-1	68	3.2		7.4		3.9
2	71	3.0	10	7.3		4.7
3	70	3.1		7.4		4.4
4	70	3.2	13	7.6	67	4.2
5	69	3.3		7.4		4.3
6	68	2.9	13	7.3		4.8
7	68	3.2		7.3		3.8
8	67	3.8		7.4		4.3
9	68	3.9	10	8.3		3.5
10	69	3.7		7.5		5.0
11	68	3.8	13	7.7		4.4
12	66	3.9		7.6		5.1
13	64	3.9	11	7.4		4.6
14	66	3.9		7.6		4.5
15	70	4.2		7.4		5.5
16	65		16	7.8		8.3
17	63					4.6
18				7.7		3.4
19						6.7
20	57	6.5				7.5
21	54	6.7		8.0		6.1
22	56	6.1		7.6		6.0
23	56	5.9	10			6.3
24	59	5.4		7.6		5.8
25	60	5.5	8	7.8		6.0
26	60	4.9		7.7		5.3
27	59	5.1				5.7
28	59	5.3		7.7		5.7
29	59	5.6		7.4		5.5
30	49	6.5	11	7.7		6.8
12-1	52	6.2		7.8		6.7
2	56	5.4	13	8.0		6.3
3	52	6.0		7.7		6.3
4	50	6.0		7.9		6.5
5	49	6.1		7.9		6.4
6	53	5.8		7.7		6.2
7	52	5.8	14	7.9		7.2
8	56	5.8		7.7		7.0
9	56	4.3		7.9		7.3
10				7.9		5.3
11	57	5.1				4.0
12	57	5.1		7.8		6.3
13	55	5.8		7.9		5.7
14	54	6.1	13	7.8		4.2
15	55	6.3		7.6		3.9
16	56	5.9	14	8.0		3.9
17	65	8.0		7.9		2.4
18	65	7.8		7.9		3.1
19	46	6.2		7.9		3.4
20	51	6.3		7.6		3.5
21	53	5.6		8.1		3.7
22	55	5.1		7.7		3.5
23						3.9
24						3.4
25						2.4
26						2.8

No other data obtained.

TABLE D-2 (Con't)

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1965	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
171	North Side WPCP Effluent, Bird Creek Sampling Sta. (Con't)		12±	1-11	51	6.3	17	7.9		4.8
				13	53	5.2	11	7.9		4.4
				18	49	6.3	18	7.9		4.7
				20	53	5.8	17	7.8		4.1
				2-1	45	7.4	20	7.9		5.4
				3	49	6.3	19	7.8		4.1
				8	54	6.1	45	7.6		4.2
				15	52	6.2	11	7.9		4.9
				17	53	5.9	12	7.8	71	4.4
				22	52	6.5	12	7.7		4.1
				24	43	8.4	11	7.8		3.9
				3-1	57	6.0	13	8.0		5.0
				3	46	7.2	21	7.9		4.9
				5	46	7.0	12	7.0		5.0
				8	52	5.8	18	7.9		5.1
				10	54	5.2	17	7.8	55	4.3
				4-5	65	4.0	13	8.0		5.6
				7	65	3.7	16	7.9		5.8
				9	65	3.3	16	7.9		4.0
				12	63	4.3	16	7.9		6.0
				13	64	4.1	16	7.9		5.5
				14	64	3.8	16	7.8		6.0
				19	65	3.8	14	7.7		6.0
				21	68	3.3	15	7.8	70.5	7.0
				22	71	3.0	20	7.5		7.0
				23	70	3.1	15	7.9		7.4
				26	62	3.9	16	7.7		6.7
				28	62	3.8	19	7.6		5.9
				5-3	69	2.7	23	7.7		6.6
				5	72	2.4	22	7.9		6.0
				12	72	3.2	15	7.7		5.2
				17	72	2.9	11	7.7		5.6
				19	73	2.2	12	7.8		5.0
				24	75	1.5	16	7.8		3.5
				26	71	1.7	22	7.7		4.1
				6-1	76	1.6		7.6		4.6
				2	75	1.1	36	7.7		4.8
				3	78	0.9		7.7		4.6
				4	78	0.8	36	7.6		4.9
				5	74	1.7		7.5		4.5
				6	73	1.5		7.3		4.0
				7	75	0.8	29	7.8		5.0
				8	76	NR		7.8		4.3
				9	76	0.9		7.7		4.8
				10	78	1.2		7.8		4.5
				11	78	0.5	32	7.6		4.9
				12	79	NR		7.4		3.3
				13	76	1.4		NR		3.8
				14	77	0.9	34	7.5		5.2
				15	76	0.8	33	7.6		4.9
				16	77	1.0	31	7.4	74	4.4
				17	76	1.0	42	7.7		4.6
				18	76	0.7	36	7.4		5.2
				19	77	0.9		7.9		3.3
				6-20	77	0.7		7.5		1.1
				21	76	2.0		7.4		4.3
				22	75	1.3		7.5		5.2
				23	78	1.3		7.7		5.7
				24	80	0.7		7.6		1.2
				25	78	0.6		7.5		3.3
				26	79	0.7		8.1		4.1
				27	80	0.5		7.8		3.9
				28	79	1.2		7.7		4.7
				29	80	1.0		7.6		4.1
				30	80	0.8		7.6		4.4

TABLE D-2 (Con't)

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1965	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	pH	Cl⁻ mg/l	Flow MGD
172	North Side Water Pollution Control Plant Raw Sewage		12 ±	1-11	61	0	175	7.5		4.8
				13	63	0	155	7.8		4.4
				18	61	0	180	7.6		4.7
				20	62	0	200	7.5		4.1
				2-1	60	0	185	7.7		5.4
				3	60	0	180	7.7		4.1
				8	60	0	240	7.5		4.2
				15	60	0	165	7.7	73	4.9
				17	60	0	190	7.8		4.4
				22	60	0	140	7.6		4.1
				24	60	0	170	7.6		3.9
				3-1	60	0	175	7.7		5.0
				3	58	0	135	7.7		4.9
				5	58	0	200	7.8		5.0
				8	59	0	185	7.7		5.1
				10	59	0	185	7.7	72	4.3
				4-5	61	0	150	7.7		5.6
				7	63	0	137	7.5		5.8
				9	65	0	140	7.[illegible]		4.0
				12	63	0	160	7.8		6.0
				13	63	0	175	7.7		5.5
				14	64	0	165	7.7		6.0
				19	64	0	120	7.5		6.0
				21	65	0	140	7.5	70.5	7.0
				22	66	0	140	7.3		7.0
				23	68	0	160	7.7		7.4
				26	63	0	230	7.5		6.7
				28	65	0	190	7.5		5.9
				5-3	65	0	135	7.6		6.6
				5	71	0	163	7.6		6.0
				12	68	0	97	7.5		5.2
				17	69	0	140	7.6		5.6
				19	70	0	143	7.6		5.0
				24	70	0	166	7.5		3.5
				26	69	0	245	7.4		4.1
				6-2			180	7.5		4.8
				6-4			190	7.5		4.9
				6-7			220	7.5		5.0
				11			190	7.3		4.9
				21			225	7.5		5.7
				23			147	7.5		5.7
				25			170	7.4		3.3
				28			250	7.5		4.7
				7-14			200	7.7		4.8

TABLE D-3

CITY OF TULSA

Station No.	Location	Stream	Mile	Date 1963	Temp. °F	B.O.D. mg/l 5 day	pH	Flow MGD
79	South Side Water Pollution Control Plant Effluent (Lt)		519.5	1-2	63	122	7.3	12.1
				3	63	63	7.6	12.0
				4	64	121	7.1	14.3
				7	63	81	7.5	13.4
				8	63	46	7.4	11.5
				9	64	70	7.3	12.7
				10	63	40	7.5	10.8
				18	61	67	7.2	11.9
				21	60	74	7.4	12.2
				22	61	140	7.4	12.1
				23	58	122	7.4	12.1
				24	59	137	7.3	12.8
				25	59	146	7.6	9.1
		Jan Average			62			
				2-4	59	136	7.5	12.3
				5	60	94	7.3	12.1
				6	60	181	7.3	11.8
				11	59	81	7.4	11.9
				12	58	160	7.4	12.0
				13	60	183	7.3	12.0
				14	59	160	7.4	9.9
		Feb Average			59			
				3-12	61	136	7.5	13.6
				15	62	112	7.2	12.3
				18	62	96	7.4	9.3
				19	62	143	7.2	12.7
				20	61	100	7.3	12.7
				21	62	181	7.4	12.2
				22	63	111	7.3	12.3
				26	64	108	7.2	12.4
				27	65	120	7.2	12.4
				28	63	140	7.8	12.6
				29	64	138	7.5	12.7
		March Average			63			
				4-1	65	116	7.4	13.2
				2	57	141	7.4	12.7
				3	66	136	7.3	12.4
				4		143	7.4	12.0
				8	67	169	7.3	12.9
				9	67	183	7.4	12.3
				10		161	7.3	12.0
				13		132	7.3	12.3
				16		151	7.3	12.8
				28	71	134	7.4	10.0
				29	70	114	7.6	9.9
				29		82	7.4	13.3
				30		95	7.4	11.9
		Apr Average			66			
				5-1	71	60	7.4	12.4
				2		63	7.5	9.8
				5	69	122	7.2	12.3
				6	71	130	7.2	12.7
				7	74	137	7.4	12.2
				9	71	96	7.2	12.6
				10	72	136	7.1	13.3
				13	71	83	7.2	12.6
				14	72	115	7.4	13.2
				15	73	141	7.2	12.4
				16	73	129	7.4	11.2
				20	72	94	7.4	11.9
				21	73	163	7.4	11.4
				22	72	139	7.4	11.4
				24	71	151	7.3	11.3
				27	71	24	7.4	12.1
				28	73	146	7.2	12.8
				29	73	141	7.2	12.3
				31		105	7.4	12.0
		May Average			72			
				6-3	74	93	7.4	13.0
				4		134	7.2	12.9
				5		144	7.0	13.0
				6		105	7.2	12.8
				7		137	7.1	12.4
				10		112	7.4	11.5
				11		131	7.1	13.0
				12		161	7.1	12.9
				13		143	6.8	12.9
				18	78	125	7.0	12.5
				19	80	119	6.9	12.7
				20	78	123	6.9	12.6
				24	79	93	7.8	13.3
				25	79	114	7.1	13.2
				26	78	140	7.0	12.4
		June Average			78			
				7-2	81	139	6.2	13.1
				3	81	161	6.5	10.4
				4	80	104	6.2	10.1
				5	81	108		12.9
				8	82	99	6.0	13.1
				9	81	172	6.0	12.9
				10	61	73	6.2	12.2
				11	80	134	6.4	9.4
		July Average			81			
				8-12	83	68	7.1	13.7
				13	83	122	7.1	13.6
				14	82	141	7.1	6.4
				15	82	39	7.3	8.3
				16	82	142	7.1	12.5
				19	83	110	7.2	13.4
				20	82	137	7.2	12.6
				21	82	134	7.1	12.2
				22	82	147	7.2	12.3
				23	82	110	7.2	12.8
		Aug Average			82.3			
				9-19	82	135	7.1	12.4
				9-20	82	146	7.0	10.8
		Sept Average			82			
				10-3	80	135		11.2
				10	80	128		15.0
				11	80	126		15.1
				23	80	193		10.2
		Oct Average			80			

Source: City of Tulsa Water & Sewer Department

TABLE D-1 (Con't)

CITY OF TULSA

No.	Station Location	Stream	Mile	Date 19 64	Temp. °F °C	B.O.D. mg/l 5 day	pH	Flow MGD
79	South Side Water Pollution Control Plant Effluent (Lt)		519.5	2-13	63	175	7.2	11.0
				2-26	62	196	6.9	9.5
				Feb Average	62.5			
				3-4	62	181	7.2	11.9
				6	63	117	7.4	11.5
				11	62	140	7.0	11.0
				13	63	170	7.3	12.2
				18	63	181	7.4	11.3
				20	62	157	7.2	12.3
				25	63	179	7.1	11.0
				Mar Average	62.6			
				4-1	64	137	7.1	11.7
				3	64	166	7.0	11.6
				8	62	128	7.2	14.2
				10	63	159	7.2	13.4
				15	65	177	7.0	12.4
				17	65	169	7.1	11.3
				22	67	163	7.1	12.1
				24	67	145	7.2	14.0
				29	70	163	7.1	12.0
				Apr Average	65.2			
				6-10	75	123	7.2	13.1
				17	78	153	7.1	11.9
				19	79	130	7.1	14.0
				24	80	152	7.0	12.8
				26	80	151	7.0	12.8
				Jun Average	78			
				7-1	80	119	6.9	14.2
				8	82	160	6.7	13.4
				10	82	133	7.3	12.5
				15	82	166	7.1	13.5
				17	82	117	7.2	13.6
				22	82	176	7.2	13.4
				24	83	169	6.9	13.1
				29	83	144	7.0	13.4
				31	83	164	7.2	13.3
				Jul Average	82.1			
				8-5	83	168	7.0	13.5
				7	86	152	7.3	13.4
				14	83	131	7.1	13.0
				19	85	153	7.3	13.5
				21	84	149	7.2	13.7
				26	83	174	7.2	13.6
				28	84	140	7.0	11.4
				Aug Average	84			
				9-2	86	171	7.1	14.0
				4	84	85	7.2	14.2
				9	83	88	7.1	13.6
				11	83	74	7.3	5.3
				16	83	116	7.2	12.6
				18	79	92	7.1	12.6
				23	81	129	7.2	13.0
				25	80	158	7.1	11.8
				30	78	199	7.1	12.0
				Sept Average	81.9			
				10-2	78	159	7.1	13.3
				7	77	152	7.3	13.1
				9	76	155	7.3	12.1
				14	78	147	7.0	11.6
				16	78	134	7.0	11.8
				21	75	149	7.1	11.7
				23	76	125	7.0	12.1
				28	67	130	7.2	13.8
				30	76	157		13.4
				Oct Average	75.7			
				11-6	76	115	7.3	13.7
				20	72	70	7.6	15.6
				25	62	150	7.2	14.5
				Nov Average	70			
				12-2	52	158	7.3	12.8
				4	52	123	7.4	13.0
				5	62	152	7.2	11.8
				9	66	95	7.4	12.5
				16	62	115	7.4	12.9
				18	63	91	7.5	12.9
				23	62	128	7.3	13.3
				30	62	114	7.4	12.6
				Dec Average	60			

Date 19 65	Temp. °F °C	B.O.D. mg/l 5 day	pH	Flow MGD
1-6	69	140	7.3	13.0
8	66	161	7.2	73.3
11	66	162	7.3	13.4
15	65	145	7.6	12.4
22	66	149	7.7	16.0
27	62	160	7.8	13.4
29	62	155	7.3	12.6
Jan Average	65			
2-3	62	151	7.2	12.9
5	62	160	7.1	12.7
10	62	77	7.4	13.6
12	62	103	7.4	10.5
17	62	98	7.4	12.6
19	62	115	7.4	12.4
24	62	141	7.3	12.3
26	62	184	7.2	13.0
Feb Average	62			
3-3	62	182	7.2	12.0
10	62	191	7.2	11.9
12	62	170	7.2	13.1
17	62	127	7.3	12.2
19	62	157	7.4	11.9
24	62	133		11.1
26	62	166	7.1	12.3
31	62	159	7.1	12.1
Mar Average	62			
4-2	62	161	7.2	11.4
7	67	146	7.0	13.8
9	67	162	7.3	13.5
14	70	184		15.8
16	61	144	7.4	14.7
21	68	172	7.3	14.2
23	70	151	7.3	13.7
28	72	194	7.4	13.1
30	71	200	7.2	12.6
Apr Average	68.7			
3-5	74	166	7.5	13.1
7	74	126	7.4	13.8
12	74	166	7.2	11.8
14	74	127	7.6	16.4
19	74	120	7.5	14.0
21	74	153	7.4	14.4
26	74	141	7.8	12.2
28	74	125	7.4	13.4
May Average	74			
6-2	76	143	7.2	14.0
4	79	129	7.4	14.2
9	79	142	7.3	14.2
11	78	150	7.4	14.1
18	78	153	7.3	14.5
25	80	99	7.4	13.8
Jun Average	78.3			
7-14		140	7.3	
16		146	7.4	
21		171	7.3	
23		170	7.3	

TABLE D-4

OTHER WATER POLLUTION CONTROL PLANTS

Station No.	Location	Stream	Mile	Date 19_63	B.O.D. mg/l 5 day	NO_3 mg/l	pH	Cl mg/l	Flow MGD
215	Haskell WPCP Effluent (Lt)			9-3	34		7.0	38	.340
				4	39		6.8	34	.375
				5	60		6.6	34	.325
				6	21		6.7	34	.311
				7	38	2	7.5	38	.947
216	Sapulpa WPCP Effluent			8-20	23	65	6.9	116	.807
				21	36	80	6.9	112	.806
				22	23	100	7.1	120	.786
				23	21	100	7.1	110	.788
				24	27	105	7.0	112	.798

TABLE D-5

STREAM QUALITY DATA

Station No.	Location	Stream	Mile	Date 1964 & 1965	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Phenol	pH	Cl⁻ mg/l	Flow CFS
116	Arkansas River at Jenks Bridge		514.8	1-14	43	11.55	3					
				27	44	10.15	6.4			8.4	995	
				2-10	51	10.0	4.8			8.1	1620	
				8-18		10.25	5.0			8.2	1345	
				9-1	80	6.1	6.5				960	
				9-15		7.7	3.5			7.8	126	
				10-8	60	8.2	7.0			8.3	780	
				10-22	60	8.8	2			7.9	723	
				11-19	60	9.1				7.9	536	
				12-10	45	9.5				7.9	64	
				31	42	12.2	2.4			7.7	254	
										8.1	930	
				1965								
				3-3	39	12.30	8.6					
				30	47	10.6	6.6			8.1	1250	
				4-13	60	10.0	1.9			8.4	900	
				27	63	8.6	1.9				572	
				6-3	78	11.5	6.25			8.1	632	
				24	78	7.6	1.8			8.6	307	
										7.8	394	
				1964								
117	Arkansas River at Bridge on Skelly and Riverside Drives		519.7	1-14	41	11.4	3					
				27	41	10.5	3.8			8.3	997	
				2-10	50	11.0	2.8			8.2	1770	
				8-18		5.4	11.0			8.3	1360	
				9-1	80	6.7	7.4				922	
				15		7.1	3.5			7.7	145	
				10-8	59	8.2	4.0			8.4	850	
				22	60	5.2	*			7.7	727	
				11-10	60	9.0				7.8	537	
				12-10	45	10.95				8.0	64	
										7.8	480	
				1965								
				3-3	39	13.7	6.1			8.1	550	
				3-30	48	12.0	4.1			8.0	925	
				4-13	57	10.2	3.3			8.1	556	
				4-27	59	8.9	1.9			8.2	625	
				6-3	76	9.6	5.4			8.7	310	
				24	77	8.1	2.1			8.0	394	
				1961								
120	Arkansas River at Sand Springs		530.3	2-2	44	5.7			0	8.4	1040	2300
				5-16	66	6.6			3	8.0	405	13200
				7-28					0			
				8-3					1			
				31	78	8.5			0	8.2	530	7900
				9-28	67	7.0			0	8.2	470	25400
				10-25	66	8.1						6330
				10-17	51	9.8						23200
				30					1			
				1962								
				1-24								
				30	40	12.9			4			
				2-19	44	10.9						12800
				3-21								7260
				4-16	55	9.4			0			
				5-16	78	7.9						4560
				6-13	78	6.0						2030
				7-11	88	5.6						18600
				8-27					0			17900
				10-16	73	10.8			0			
				11-13	53	12.3						3520
				12-12	32	13.9						2210
												3080
				1963								
				1-22	35	13.4		3	3			1600
				2-5	37	13.4		4				2400
				3-12	56	12.9		*				4240
				4-2	69	8.5						5300
				4-30	63	8.6		7				3630
				6-4	82	7.0		4				3020
				7-8	87	7.5		*				3260
				8-8					4			
				9-16	75	8.0		*				6340

TABLE D-5 (Con't)

Station No.	Location	Stream	Mile	Date 1961	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Phenol	pH	Cl⁻ mg/l	Flow CFS
137	Arkansas River at Bridge E of Muskogee on US HWY 62		457.8	10-24	67	8.6						
				11-15	53	9.9			3			22600
				12-13	37	12.6			4			40300
												34700
				1962								
				1-25								
				2-20	45	10.5			2			11000
				3-20	61	13.4						21900
				4-16	58	9.4			0			8860
				5-15								14700
				5-16	73	8.2			1			5200
				6-12	78	5.1						5220
				7-12	83	5.0			0			71700
				8-29	82	8.5			1			26400
				11-14	58	12.8			0			4920
				12-13	35	13.3						5780
												7180
				1963								
				2-6	50	12.5	4					
				3-13	51	12.3	4					5340
				4-3	68	9.2						24700
				5-1	67	9.1	7					8920
				6-5	87	7.6	5					5420
				7-9	90	8.6	3					3920
				8-8	82	6.2	4					7920
				9-17	80	7.5	6					5560
												9850
139	Verdigris River Bridge at State HWY 33 West of Inola		48.8	1961								
				9-13	67	4.4			14	7.6	27	66600
				8-2					2			
				29	79	6.7				8.1	80	1960
				30					0			836
				9-27	67	7.8				7.8	24	20600
				10-25	62	7.9						2560
				11-15	53	10.0			0			16300
				12-14	38	12.0			0			5950
				1962								
				1-29								
				2-9	33	13.6						11700
				3-21	54	12.0			0			6510
				5-16	57	6.2			0			10600
				5-15		9.2						2180
				16	76	8.8			2			
				6-13	76	6.8						333
				7-12	88	4.6			0			4560
				7-13								2080
				8-29	80	7.1			0			1410
				10-17	73	7.5			0			50
				11-16	55	9.7						1200
				12-12	40	12.5						344
												709
				1963								
				2-6	42	13.0						
				3-13	49	11.5						586
				4-3	68	7.4						5970
				5-1	67	9.1						1820
				6-5	84	10.2						317
				7-9	89	6.8						131
				8-8								38
				9-17	80	13.9						48
												38
191	Bird Creek near Catoosa Approximately 1 ½ miles NW at Bridge		2.8	1963								
				2-7	62	9.7	7.0					
				3-28	63	7.6	7.56			7.7		
				4-11	64.5	7.2	8.1			7.7		
				5-30	75	4.3	9.1			7.8		
				8-8	86	4.8	3.0			7.35		
				10-30	62.5	4.6	7.4			7.6		
				11-15	53.5	5.6	6.2			7.75		
				12-26	40.5	6.2	8.2			7.5		
				12-5	49	6.2	7.4					
				12-19	37	6.6	13.4			7.5		
		1964		12-17	39	10.0	3.0			7.4		
										8.1	96	
		1965		1-21	40.5	9.8	7.3					
				2-18	42	10.4	3.9			8.1	118	
				4-22	67.5	3.8	4.1			8.1	120	
										7.2	47	

TABLE D-5 (Con't)

Station No.	Location	Stream	Mile	Date 1963 & 1964	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	pH	Cl⁻ mg/l	Flow CFS
194	Bird Creek at Bridge on 56th Str. east of Turley		21.8	2-7	41	10.0	4.4		7.7		57
				3-28	63.5	7.8	4.58		7.8		59
				4-11	64.5	7.2	3.6		7.8		71
				5-30	75	4.6	6.9		7.4		35
				8-8	87	3.4	2.8		7.7		4
				10-20	62.5	3.9	9.7		7.8		
				11-15	51	5.6	5.4		7.6		
				12-26	38	4.6	7.8		7.9		
				12-5	47	7.0	8.1		7.7		
				12-19	34.5	7.0	9.8		7.5		
		1963 Avg.			60.7	6.3	6.5		7.7		
				1964							
				12-17	37	12.0	1.4		8.3	98	
				1965							
				1-21	40	13.2	3.8		8.4	304	
				2-18	42	12.2	2.5		8.3	106	
				4-2	68.2	7.4	1.7		7.8	43	
				6-3	78	6.4	1.6		7.6	76	
		Average			73.8	8.2	3.0		7.7	126	
				1961							
205	Verdigris River at Bridge in Okay on Hwy 16		3.6	5-9	65	4.7					50,000
				6-1							7,000
				8-29	78	6.9					1,000
				9-26	69	7.3					22,000
				10-24	66	7.9					2,400
				11-15	54	9.8					16,500
				12-13	38	12.0					7,600
				1962							
				1-23							1,200
				1-29							11,700
				2-20	47	10.7					3,400
				3-20	55	13.1					1,700
				4-16	57	8.9					2,100
				5-15							340
				5-16	78	10.1					320
				6-12	76	5.0					5800
				7-17	86	7.4					2000
				8-29	83	9.0					50
				10-17	73	7.4					1100
				11-14	57	11.3					340
				12-13	40	12.4					630
				1963							
				2-6	42	13.4		5			930
				3-13	48	10.8		3			8800
				4-1	68	6.6					1700
				5-1	68	11.1		7			300
				6-5	87	10.8		6			120
				7-9	87	6.5		5			38
				8-8	84	4.7		6			45
				9-17	83	9.8		5			35

APPENDIX "E"

RESULTS OF ANALYSES - 1965 SURVEY

TABLE E-1

SAMPLES COLLECTED AT WATER POLLUTION CONTROL PLANTS

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl mg/l	Flow MGD
79	South side WPCP Tulsa to Muskogee		519.5	8-11			140	357	21.29	19.0	0.05	0.0	49.0	35.0		52	
				12			140	322	24.87	22.4	0.03	0.4	45.0	30.0		52	
89	Sand Springs Water Pollution Control Plant		528.8	8-16	27	4.0	100	319	39.72	32.8	0.22	3.9	75.0	22.5	7.3	90	
113	Sunray DX Waste Treatment Plant Effluent			8-16	30	2.5	27	122	13.52	13.0	0.03	0	0.8	0.2	10.1	112	
167 & 168	Coal Creek Water Pollution Control Plant Effluent, Enters Bird Creek		18.9	7-7	25	3.7	88	381	16.27	12.9	0.27	2.0		25.0		54	3.1
				8	26	4.5	39	182	19.35	12.0	0.40	5.83	59.0	45.0	7.5	60	3.2
				9	26	3.3	32	232	16.41	14.0	0.36	2.65	60.0	50.0	7.6	52	3.1
				14			92								7.6		3.6
				16			45								7.3		3.0
				21			86								7.8		2.7
				23			37								7.4		2.7
			July Average		26	3.8	53	265	17.34	13.0	0.34	3.50	57.3	40.0	7.6	55	3.1
171	North Side Water Pollution Control Plant, Effluent, Bird Creek Sampling Sta		12+	7-7	26	2.7	13	73	5.35	3.4	0.61	8.5		60		80	
				8	27	2.6	11	94	24.60	1.7	.50	21.6	70	55	7.3	86	
				9	27	1.8	6	113	11.61	3.1	.61	6.8	70	70	7.6	72	
				14	25		12								7.6		
				19	27	2.0	12	81	3.1	2.1	.61	42	62.5	60	8.0	90	
				20	26	1.3	11	30	3.9	3.1	.70	62	70	62	7.6	58	
				21	27	2.2	7	67	3.3	2.5	.54	37.6	75	55	7.6	84	
				22	27	1.9	10	59	3.3	2.7	.70	35.4	70	55	7.9	76	
				23	28	1.9	10	39	3.2	2.6	.62	42	62.5	55	7.8	76	
				24	28	1.3	10	86	3.4	2.7	.65	51	80	52.5	7.3	78	
				25	27	0.9	12	82	3.6	2.7	.62	28.4	75	65	7.1	80	
172	North Side Water Pollution Control Plant Raw Sewage		12+	7-19	26	0	193	592	24.93	23.8	0.33	0	70.0	57.5	7.6	100	5.1
				20	26	0	240	688	23.03	20.2	0.03	0	95.0	82.5	7.5		5.3
				21	26	0	165	588	22.80	20.2	0.40	0	77.5	60.0	7.5	82	5.3
				22	26	0	160	570	23.66	20.2	0.06	0	70.0	55.0	7.4	78	5.3
				23	27	0	180	618	23.84	21.3	0.04	0	70.0	57.5	7.5	76	5.3
				24	26	0	195	578	26.93	24.1	0.03	0	75.0	55.0	7.4	80	5.0
				25	26	0	210	586	22.12	21.3	0.02	0	75.0	65.0	7.5	88	5.0
				28			196								7.8		

TABLE E-1 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °F	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl⁻ mg/l	Flow MGD
173	Stabilization Pond Effluent to Mingo Creek			8-4	30	14.0	8 filtered 20 unfiltered	228	8.69	6.44	0.08	0.17	16.0	7.5	9.0	40	0.15E
175	Flat Rock Water Pollution Control Plant, Raw Sewage		20.3	8-16			185	560	28.24	26.0	0.016	1.33	52.5	51.0	7.6	151	4.8
176 & 177	Flat Rock Water Pollution Control Plant Effluent		20.3	8-16	27		46	211	22.38	20.7	0.066	0.089	46.0	46.0	7.8	155	4.8
				7-7	24		60	236	17.90	16.2		0.5		29.0		146	4.9
				9	25		35	312	18.55	17.5	0.05	0.2	70.0	60.0	7.5	158	4.7
178	Sperry Water Pollution Control Plant Effluent to Hominy Creek		5±	7-7	26	5.0	23	76	11.2	5.6		4.8		40.0	7.0	66	0.029
				8	25	2.7	29	131	13.2	9.0	1.5	1.7		35.0	7.3	80	0.029
				9	25	2.4	11	131	21.6	9.1	2.0	6.1	35.0	35.0	7.3	64	0.029
				Avg July 1965	25.3	3.36	21	113	15.3	7.9	1.8	4.2	35.0	35.0	7.2	63	0.029
182	Owasso Lagoons Effluent		11.3	7-30	filtered 30 unfiltered		8 32	179	2.87	0.84	0.03		7.5	2.5	9.7	74	
185	Collinsville WPCP Effluent to Blackjack Creek (1 mile from Mouth), to Horsepen Creek to Caney River below Station No. 197		1	8-2	27	2.1	21	108	24.95	23.52	0.03		20.0	20.0	7.2	190	
				3	28	2.6	26	93	34.42	33.0	0.02		70.0	32.5	7.0	146	
				4	28	2.8	21	143	27.74	27.0	0.03	0.15	142.5	89.0	7.2	134	
				Avg Avg	27.7	2.5	23	113	29.04	27.84	0.03	0.05	77.5	49.8	7.1	33	
186	Tulsa Rendering Plant Wastes Lagoons - next station No. 185		1	8-2	28 unfiltered	15.0	filtered 11 21	210	16.03	12.88	0.20	0.15	9.0	3.0	9.0	228	
				3	30 unfiltered	13.0	8 26	143	21.42	10.1	0.41		24.0	6.0	9.5	224	
				Avg Avg	29	14.0	10 f 24 un	176	18.72	11.44	0.30	0.08	16.5	5.5	9.2	226	
187	Barnsdall Water Pollution Control Plant Effluent		67.5	7-12	27	0.0	205	962	41.12	33.6	0.02	0.2	165	67.5	6.7	90	
				13	22	0	200	644	41.11	37.5	0.01	0.2	135	40	6.6	102	
				14	27	0	235	522	36.49	32.5	0.04	0.05	90	50	6.5	102	

TABLE B-1 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Flow MGD
188	Pawhuska Water Pollution Control Plant Effluent		85	7-12	28	0.6	23	127	22.59	10.4	2.4	6.9	77.5	50.0	7.0	84	
				13	29	0.8	49	100	21.40	11.5	2.0	5.7	60.0	25.0	7.0	86	
				14	25	3.0	33	100	10.80	2.5	0.4	6.25	17.5	15.0	6.8	28	
		Avg July			27.3	1.5	35	109	18.23	8.1	1.6	6.28	51.7	30.0	6.9	66	
189	Claremore S.T.P. to Verdigris		55	7-20	28	4.0	24	144	20.14	13.2	0.36	4.9	57.5	45.0	7.0	194	
				21	28	3.8	22	97	17.40	10.0	0.90	4.5	52.5	40.0	7.0	202	
				22	28	3.5	14	48	14.00	9.0	0.40	2.9	40.0	20.0	7.3	194	
		Avg July			28	3.8	20	96	17.18	10.7	0.55	4.1	50.0	35.0	7.1	197	
201	Bartlesville WPCP Effluent		68.3	7-15	28	0.4	72	234	11.05	10.9	0.03	0.1	40.0	12.5	7.0	140	
				16	28	0.1	90	433	21.94	21.8	0.04	0.1	45.0	20.0	7.0	110	
				19	28	2.8	6	37	13.6	10.93	0.14	6.53	42.5	42.5	6.5	156	
		July Avg.			28	1.1	56	235	15.53	14.54	0.08	2.24	42.5	25.0	6.8	135	
202	Washington County Improvement District No. 2 WPCP		63±	7-15	31	20.0	12	56	3.33	0	0.23	1.7	6.2	2.5	9.3	314	
				16	32	21.3	6	56	2.07	0	0.24	1.2	5.0	1.3	9.5	420	
		Avg.			31.5	20.6	9	56	2.70	0	0.24	1.45	5.6	1.9	9.4	367	
210	Broken Arrow WPCP Effluent (½ upstream on Haikey Creek which is a tributary to Arkansas River (R))		½	8-11	25	3.0	31	119	53.2	11.8	33.0	7.0	65.0	60.0	7.5	82	
				12	29	2.8	13	87	10.44	5.3	0.14	4.3	67.5	62.5	7.5	72	
				13	26	3.5	72	79	17.57	14.8	0.64	1.3	70.0	54.0	7.5	90	
		Avg. Avg.			26.6	3.1	39	95	27.07	10.63	11.26	5.86	67.5	58.8	7.5	70	
212	Muskogee WPCP Effluent		At±	7-28	27	2.7	91	150	16.45	14.0	0.21	0.0	32.5	15.0	7.0	70	
				8-9	28	0	130	365	17.45	14.6	0.05	0	52.5	35.0	7.0	70	
				10	28	0.3	113	294	23.15	20.4	0.05	0.6	49.0	34.0	7.0	100	
				16	28	1.5	113	343	24.06	21.0	0.04	0.5	42.5	25.0	6.8	78	
		Avg Avg.			27.8	1.1	105	288	20.28	17.5	0.09	0.28	44.1	27.2	7.0	80	
213	Rolling Hills WPCP Effluent			8-4	28	14.0	12 mil. 26 anfil.	264	20.36	17.6	0.09	0.17	55.0	49.4	8.5	30	

TABLE E-1 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Flow MGD
214	Taft WPCP Effluent			8-17	28	1.8	99	185	14.58	9.0	0.40	3.5	32.5	17.5	6.8	40	
				8-18	29	0.8	73	185	18.34	14.0	0.7	1.4	22.5	15.0	6.9	34	
		Aug Avg.			29.5	1.3	86	185	16.46	11.5	0.55	2.45	27.5	11.3	6.8	37	
215	Haskell WPCP Effluent (Lt)			8-16	26	8.5	8 fil 32 until	169	3.19	1.12	0.11	0	20.	19	8.1	46	
				8-17	27	7.0	10 fil 28 until	126	3.01	1.54	0.07	0	20	19	7.9	46	
				8-18	29	7.5	10 fil 22 until	138	3.29	1.2	.40	0.5	24.5	18	7.6	44	
216	Sapulpa WPCP Effluent			8-13	27	3.6	25	155	24.24	8.4	.50	13.1	75	65	6.6	140	
				16	27	3.7	20	146	15.70	7.3	.50	6.5	65	40	7.0	112	
				18	28	2.8	17	134	23.82	7.6	.54	14.0	75	66	6.8	136	
		Avg Avg 1965			27.3	3.4	21	145	21.25	7.8	.51	11.2	71.7	57.0	6.8	129	

TABLE E-2

STREAM SAMPLES

Station No.	Location & Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Coli MPN Confirmed	Fecal Coliform	Flow CFS
116	Arkansas River at Janks Bridge	514.8	8-4	26	13.3	4	43	.32	0	.04	0	1.2	0.6	8.5	216			3040
			5	27	11.0	4	39	.19	0	.05	0	1.4	0.5	8.4	228			3000
			6	26	10.0	3	29	.24	0	.03	0	0.8	0.5	8.4	254			2930
			17	28	7.0	5	24	.63	0	.07	0	2.4	1.4	8.8	298			1950
117	Arkansas River Bridge at Interstate HWY 44, 51st St. Tulsa	519.7	8-4	27	9.8	4	39	0.16	0.0	0.02	0.0	1.6	0.8	8.3	210	4900/4900		3040
			5	28	9.5	3	43	0.31	0.0	0.03	0.0	1.5	1.0	8.3	230			3000
			6	27	8.8	5	39	0.45	0.0	0.03	0.0	1.2	0.7	8.4	276	2200/2200		2930
138	Grand-Neosho River just below Ft Gibson Dam at Hwy 16	6.6	7-23	28	7.0	3	7	0.73	0.0	0.02	0.50	0.5	0.2	8.5	16			6300
			26	32	6.0	2	4	0.85	0.0	0.01	0.35		0.4	8.1	20			5500
			27	29	7.0	3	0	0.78	0.0	0.03	0.40	0.6	0.3	7.8	18			4410
			28	28	6.5	2	0	0.62	0.0	0.04	0.30	0.5	0.0	7.5	16			1900
			8-12	28	7.3	3	12	0.91	0.0	0.05	0.65	0.8	0.0	8.4	18			2560
			9													278/63		3000
			11													278/221		3120
			13													63/63		2550
		July & Aug Avg		29	6.8	2.6	5	0.78	0.0	0.03	0.44	0.65	0.3	8.1	18	206/116	169/82	4134
137	Arkansas River at Bridge East of Muskogee on US HWY 62	457.8	7-23	30	8.7	4	14	0.69	0.0	0.01	0.4	0.7	0.4	9.0	68			6450
			26	33	9.3	5	18	0.57	0.0	0.01	0.0		0.4	8.3	148			4170
			27	32	8.5	7	22	0.29	0.0	0.01	0.0	2.2	1.1	8.3	212			3280
			28	30	8.0	5	7	0.47	0.0	0.05	0.0	1.3	0.0	8.4	186			5420
			8-12	29	9.5	8	44	1.03	0.0	0.04	0.5	1.7	1.5	8.9	196			2490
			8-9													70/50		3660
			11													23/5		3200
			13													33/17		
139	Verdigris River Bridge at State HWY 33 West of Inola	48.8	7-20	29	6.0	3	15	0.61	0.0	0.03	0.03	2.0	0.7	7.3	110			462
			21	29	6.0	3	0	0.60	0.0	0.03	0.15	2.0	1.3	7.3	132			320
			22	29	6.0	3	0	0.33	0.0	0.05	0.0	1.6	0.7	7.3	116			290
			26	32	9.3	3	21	0.69	0.0	0.06	0.06		1.5	7.6	168	200/200		169
			28													330/79		146
			29													23/23		125
		July Average	1965	29.8	6.8	3	9	0.56	0	0.04	0.13	1.9	1.2	7.4	132	184/101	113/71	310

TABLE E-2 (Con't)

No.	Station Location & Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Coli MPN Confirmed / Fecal Coliform	Flow CFS
141	Hominy Creek at Bridge on Highway 20, six miles east of Skiatook	16.8	7-12	31	8	4	44	0.71	0.0	0.01	0.2	1.4	0.0	7.6	348		5.2
			13	32	8	4	48	0.51	0.0	0.01	0.0	0.5	0.0	7.8	348	13000 / 800	3.0
			14	27	7	4	26	0.36	0.0	0.01	0.0	0.3	0.2	7.4	320		40
			16													4600 / 2300	64
	3 Day Average			30	7.7	4	39	0.53	0	0.01	0.07	0.73	0.07	7.6	339	5867 / 1033	400 / 123	16.1
142	Bird Creek at Avant Cage 1½ miles upstream from Candy Creek	54.2	7-12	30	8.4	4	22	0.41	0.0	0.01	0.2	1.3	0.2	7.7	44	200 / 0	35
			13	31	8.1	4	19	0.36	0.0	0.01	0.0	0.5	0.0	7.9	40		32
			14	29	6.0	4	11	0.36	0.0	0.01	0.0	0.5	0.5	7.5	38	3400 / 600	75
			16													1300 / 330	70
	Average July			30	7.5	4	17	0.38	0	0.01	0.07	0.77	0.23	7.7	41	1633 / 310	961 / 58	47.3
143	Verdigris River Bridge on State HWY 20 west of Claremore	76.0	7-20	29	7.0	3	22	0.52	0.0	0.04	0.2	0.9	0.4	7.5	88			
			21	29	7.0	2	0	0.42	0.0	0.04	0.1	1.2	1.0	8.0	104			984
			22	30	7.0	14	15	11.12	6.2	0.28	3.8	43.0	16.0	7.5	200			255
			28	30	6.5	6	7	0.4	0.0	0.02	0.0	0.6	0.1	8.5	86			204
			29	28	8.0	6	11	0.43	0.0	0.03	0.0	0.4	0.0	8.5	88	70 / 33		59
			30	28	8.8	4	0	0.29	0.0	0.01	0.0	0.0	0.0	8.3	94	23 / 8		59
			8-11	28	7.3	3	40	0.32	0.0	0.04	0.0	0.3	0.0	8.5	93			59
	July & Aug Avg.			28.9	7.4	5.4	14	1.94	0.9	0.07	0.6	1.1	2.5	8.1	108	58 / 30	23 / 24	38
																		237
154	Mouth of Joe Creek near 91st & Lewis	515.2	8-2													330 / 230		
			8-4													34200 / 34800		
			8-6													2300 / 1300		
			8-6	26	8.5	4	179	0.71	0.0	0.01	0.0	0.7	0.1	7.5	1445			
			8-13	26	6.1	4	83	0.82	0.0	0.02	0.45	0.9	0.1	7.3	2160			
			8-17	25	6.4	7	19	1.27	0.0	0.05	0.80	0.3	0.3	7.0	260			
	Average			25.6	7.0	5	95	0.93	0	0.003	0.42	0.7	0.2	7.3	1305			0.001E
156	Broken Arrow Creek near mouth (Rt)		8-2															
			8-4													1750 / 700		
			8-6													34200 / 7000		
																34800 / 4900		

TABLE E-2 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl⁻ mg/l	Coli MPN Confirmed Fecal Coliform	Flow CFS
158	Bailey Creek Mouth near 141st & 114th E Ave S. (Rt)		502.8	8-11	28	10.5	6	48	0.38	0.0	0.03	0.0	1.6	1.1	8.5	264		
				8-12	25	6.5	3	20	0.83	0.0	0.04	0.65	5.0	3.4	7.5	54		
				13	25	6.5	3	16	7.22	0.0	0.11	0.7	6.0	5.0	7.5	118		
		Average			26	7.8	4	28	2.81	0.0	0.06	0.45	4.2	3.23	7.8	145		1872
				8-2													10900	
				8-4													4900	
				8-6													3300	
																	490	
																	4900	
																	2309	
160	Mouth of Snake Creek (Lt)		504.8	8-2	30	7.8	8	0	0.31	0.0	0.03	0.0	0.5	0.5	7.5	132		
				3	29	8.5	4	0	0.31	0.0	0.03	0.0	0.7	0.1	7.9	128		
				4	28	7.5	4	43	0.39	0.0	0.03	0.15	0.8	0.2	7.4	124		
				9														
				11													790	
				13													220	
																	80	
		Average			29	7.9	5	14	0.34	0	0.03	0.05	0.7	0.3	7.6	128	50	
																	9	
																	0	
																	290	86
																	90	48
161	Mouth of Posey Creek (Lt)			8-2														
				4													330	
				6													330	
																	25	
																	50	
																	790	
																	220	
162	Arkansas River (Lt) Polecat Creek, Bridge on Peoria		513.6	5-4	26	10.0	7	71	0.32	0.0	0.04	0.0	0.4	0.1	7.9	440	800	
				5	28	9.3	0	71	0.29	0.0	0.01	0.0	0.9	0.1	7.8	430	110	
				6	27	6.0	4	57	0.29	0.0	0.01	0.0	0.6	0.0	7.5	408		
		Average			27	8.5	6	66	0.03	0	0.02	0	0.7	0.1	7.7	426	330	
				8-2													10	
																	330	
																	80	
180	Bird Creek at Skiatook Water Pollution Control from Lagoons. No effluent at this time.		33	7-29	28	14.0												
				29	filtered		9		203	17.17	2.0	0.07	5.0	35.0	24.0	8.5	62	No overflow
				29	unfiltered		24											

TABLE E-2 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Coli MPN Confirmed / Fecal Coliform	Flow CFS
190	Dog Creek South of Claremore Trib. to Verdigris		55	7-20	27	3.5	6	30	0.66	0.3	0.11	0.25	6.8	5.5	7.0	62		
				22	31	4.0	7	15	0.63	0	0.07	0	5.5	3.8	7.1	64		
				26													700/130	
				28													345/172	
				29													79/79	
																	Confirmed Fecal Coliform	
				Avg July	29	3.8	6	22	0.64	0.2	0.09	0.12	6.2	4.6	7.0	63		
191	Bird Creek near Catoosa Approx. 1½ miles NW at Bridge		2.8	6-3-65	77	3.5	8.4	44.5	8.34	2.24	0.72	5.1	2.0	1.5	7.45	78		
				7-7	28	2.7	6	76	1.27	0	0.12	0.85	-	1.8	7.1	84		120
				7-8	28	3.0	3	36	1.31	0.6	0.11	0.4	3.6	2.8	7.1	120		150
				9	27	3.1	2	33	2.44	0.8	0.14	0.4	3.6	2.0	7.0	96		160
				20	28	3.0	3	0	1.50	0.4	0.22	0.6	3.4	2.8	7.1	98		70
				21	29	3.5	3	7	2.30	0.35	0.25	1.0	5.0	3.0	7.1	98		60
				22	29	4.0	4	7	1.92	0.63	0.27	0.6	4.6	3.7	7.1	.02		53
				8-10	28	6.2	7	48	3.55	0	0.32	2.6	10.5	9.0	7.8	185		20
192	Caney River about 3 miles E above mouth			7-19	30	5.9	3	48	15.33	14.6	0.03	0.3	1.2	0.3	7.4	90		770
				16	30	5.8	3	11	0.51	0	0.01	0.2	0.9	7.8	7.8	138		480
				19	29	5.8	3	15	1.13	0	0.08	0.7	0.9	0.4	7.4	182		200
				8-2	29	7.3	4	0	0.32	0	0.04	0.0	0.2	0.1	8.0	182		15
				3	27	7.8	3	0	1.16	0	0.04	0	1.0	0.4	8.1	164		10
				7-20														
				7-21													2300/800	
				7-23													1300/170	
				July & Aug. Avg	29	6.5	3.2	15	3.69	2.92	0.04	0.24	0.67	0.28	7.7	151	330/0	295E
193	Verdigris R. at Oologah Dam		90.0	7-23	28	7.0	3	14	0.59	0	0.03	0.35	0.6	0.2	7.2	46		120
				27	29	6.5	5	22	0.34	0	0.02	0.10	0.7	0.4	7.6	50		32
				21	28	7.0	3	0	0.61	0	0.02	0.10	1.6	0.2	7.5	44		157
				26													490/220	58
				28													700/230	32
				29													940/130	32
				July avg.	28.3	6.8	3.7	12	0.58	0	0.02	0.18	0.97	0.27	7.4	47		103

TABLE E-2 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Coli MPN Confirmed / Fecal Coliform	Flow CFS
194	Bird Creek at Bridge 56th St. east of Turley		21.8	7-7	28	7.2	2	18	1.38	0	0.03	0.95	-	0.5	7.4	72		105
				8	29	6.1	1	44	0.73	0	0.03	0.3	2.2	1.0	7.3	92		125
				9	29	6.5	2	36	1.09	0	0.04	0.25	0.8	0.6	7.3	150		145
				12	31	9.5	5	32	0.73	0	0.03	0.2	0.8	0.6	7.5	136	800 / 500	55
				13	31	8.0	2	15	0.29	0	0.01	0	1.0	0	7.7	164		53
				14	28	5.0	8	48	0.53	0	0.03	0.1	2.0	0.4	7.4	114	22100 / 10900	90
				16													4900 / 2300	
	July Avg.				29.3	7.1	3.3	32	0.79	0	0.03	0.30	1.4	0.5	7.4	121		96E
196	Caney River at Bridge below Bartlesville WPCP		67±	7-12	28	7.0	19	52	6.07	4.5	0.08	0.3	7.4	3.1	7.5	234		750
				16	28	6.0	7	74	2.34	1.9	0.14	0.3	2.5	1.3	7.0	170		470
				19	29	3.5	8	37	2.04	0.4	0.14	1.1	22.5	4.4	7.0	162		190
				20													54000 / 13400	
				21													17200 / 4900	
				23													4900 / 4900	
	July Avg.				28.3	5.5	11.3	54	3.48	2.26	0.12	0.56	16.5	2.9	7.2	195		420
197	Caney River at Bridge N. E. of Collinsville on US HWY 169		15.8	7-15	28	6.0	3	0	0.54	0	0.04	0.2	1.6	0.1	7.4	96		770
				16	28	5.0	4	48	0.35	0	0.05	0.3	1.7	0.1	7.2	170		480
				19	29	6.5	3	44	0.57	0	0.04	0.25	0.8	0.4	7.5	170		200
				8-2	28	7.8	4	0	0.22	0	0.01	0	0.4	0.1	7.8	246		15
				3	29	7.0	3	0	0.26	0	0.01	0	0.8	0.3	7.3	240		10
				7-20													2210 / 170	
				21													490 / 140	
				23													490 / 0	
	Avg				28.4	6.46	3	19	0.40	0	0.03	0.15	1.1	0.2	7.4	184		293
199	Horsepen Creek below Station 197 and about 1 mile above mouth.		15.4	7-15	28	6.0	6	41	0.24	0	0.04	0.2	1.9	0	7.3	93		
				16	30	6.0	5	0	0.57	0	0.07	0.1	0.3	0	7.4	90		
				19	29	12.0	9	89	0.47	0	0.05	0	1.2	0.2	7.8	98		
				20													700 / 2000	
				21													700 / 0	
				23													2300 / 230	
	Avg.				29	7.3	7	43	0.43	0	0.05	0.1	1.1	0.1	7.3	93		

TABLE E-2 (Con't)

Station No.	Location	Stream Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Coli MPN Confirmed / Fecal Coliform	Flow CFS
200	Bird Creek below Pawhuska WPCP	75	7-12	29	7.8	4	30	0.75	0.0	0.05	0.3	1.2	0.9	7.5	54	70000 / 23000	
			13	29	68	3	0	0.64	0	0.04	0.2	1.3	0.3	7.5	[illegible]		
			14	26	7.3	7	33	1.00	0	0.05	0.4	1.7	0.9	7.5	[illegible]	240000 / 79000	
			16													109000 / 33000	
		July Avg.		28	7.3	5	21	0.80	0	0.05	0.3	1.6	0.7	7.5	46		
203	Wagoner Water Pollution Control Plant on Rose Creek Tributary to Coal River, Tributary to Verdigris South of Wagoner	8	7-23	29	2.0	24	86	10.16	6.7	0.16	2.9	70.0	65.0	7.0	72		
			7-27	29	2.0	19	90	36.89	26.9	0.69	5.4	80.0	75.0	7.0	72		
			7-29	27	2.0	19	71	15.90	7.0	0.7	6.8	60.0	49.0	7.0	76		
			7-30	28	2.0	19	71	16.61	7.6	0.69	7.2	75.0	47.5	7.0	80		
		Avg.		28.2	2.0	20	80	19.89	12	0.56	5.6	71.2	59.1	7.0	75		
204	Coal Creek Near Mouth Trib. to Verdigris S.W. of Wagoner	11.3	7-23	30	7.0	8	50	0.53	0	0.04	0	4.4	4.2	7.8	214		0.6
			27	29	4.3	10	64	0.59	0	0.02	0.15	4.8	4.6	7.0	222		0.6
			29	27	3.8	7	36	1.08	0.21	0.08	0.3	3.8	2.4	6.5	150		0.6
			30	26	3.0	6	36	1.10	0.28	0.05	0.35	3.2	3.2	6.5	170		0.6
		July Avg		28	4.3	8	46	0.82	0.12	0.05	0.20	4.0	3.6	7.0	189		
205	Verdigris River	3.6	7-21	32	7.7	4	0	0.59	0	0.01	0.3	0.8	0.3	7.5	96		250
			26	34	12.0	8	61	0.43	0	0.01	0	-	0.8	9.0	104		170
			27	32	13.5	6	15	0.36	0	0.01	0	0.6	0.3	8.5	100		160
			28	29	5.8	8	21	0.63	0	0.07	0	1.8	0.5	7.5	66	5420 / 3420	150
			8-5	30	9.3	8	43	0.31	0	0.03	0	0.6	0.1	8.6	116		82
			9	32	9.0	3	24	0.32	0	0.04	0	0.4	0.1	8.4	114		75
			7-29													426 / 141	
		July & Aug Avg.		31.5	9.6	6	27	0.44	0	0.03	0.05	0.7	0.4	8.2	99		148
207	Arkansas River at Bridge South of Coweta on Hwy 72	466.2	7-29	27	13.0	7	14	0.56	0	0.01	0	1.5	0.5	8.5	172		
			30	28	7.8	9	25	0.29	0	0.01	0	0.8	0.6	9.0	190		
			8-6	27	11.9	7	0	0.39	0	0.04	0	1.0	0.8	9.	226		
			16	26	8.5	5	22	0.32	0	0.04	0	1.3	0.9	8.5	260		
			8-9													220 / 220	
			8-11													90 / 90	
			8-13													200 / 110	
		July & Aug Avg.		27	10.3	7	15	0.34	0	0.025	0	1.2	0.7	8.75	212		

TABLE B-2 (Con't)

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl⁻ mg/l	Coli MPN Confirmed Fecal Coliform		Flow CFS
208	Arkansas River at Bridge North of Muskogee on US Hwy 69		461.8	7-26	31	7.8	6	107	0.42	0	0	0	-	1.1	9.0	210			
				28	30	6.3	9	21	0.32	0	0.04	0	1.8	0.7	9.0	186			
				8-6	28	8.6	8	43	0.58	0	0.02	0	1.2	0.6	9.0	220			
				9	28	8.6	7	8	0.57	0	0.01	0	1.0	0.4	9.4	314			
				10	29	8.8	6	44	0.32	0	0.03	0	1.6	1.0	9.0	295			
				18	29	9.5	7	35	0.14	0	0.01	0.4	1.6	0.8	9.5	256			
				11													23 / 2		
				13													109 / 17		
	July & Aug Avg.				29.2	8.3	7	43	0.39	0	0.02	0.07	1.44	0.62	9.2	247			
209	Verdigris River Bridge west of Wagoner on Hwy 51		22.3	7-26	30	8.0	4	0	0.51	0	0.02	0	-	0.8	8.0	114	109 / 23		180
				29	29	8.0	4	7	0.49	0	0.04	0.1	0.9	0	7.9	108			150
				30	29	7.5	5	7	0.31	0	0.03	0	0.32	0.32	8.5	118			115
				28													109 / 79		
	July Avg.				29.3	7.8	4	5	0.44	0	0.03	0.03	0.61	0.37	8.1	113	109 / 51	109 / 43	
211	Polecat Creek above Sapulpa WPCP (It)		8-13		27	6.9	3	64	1.96	0.43	0.12	1.0	4.3	3.2	7.3	476			
				16	25	7.0	3	47	0.44	0	0.02	0	0.2	0.1	8.0	286			
				17	26	6.3	2	12	0.44	0	0.02	0	0.2	0.04	7.5	228			
	Aug Avg.				26	6.6	3	41	0.95	0.16	0.05	0.3	1.57	1.11	7.6	330			

TABLE E-3

MISCELLANEOUS SAMPLES

Station No.	Location	Stream	Mile	Date 1965	Temp. °C	D.O. mg/l	B.O.D. mg/l 5 day	C.O.D. mg/l	Nitrogens mg/l Total	NH_3	NO_2	NO_3	Phosphate mg/l Total	Ortho	pH	Cl^- mg/l	Flow MGD
151	Tulsa 8' x8' Storm Sewer at Riverside Dr & 36 St		519.3	8-1	25	6.9	4	8	1.08	0	0.04	0.35	1.9	0.8	8.4	30	0.11
				17	25	6.8	3	24	1.23	0	0.05	0.9	1.2	0.7	7.3	22	
			Average		25	6.8	4	16	1.16	0	0.04	0.72	1.1	0.8	8.0	26	
159	Bixby Waste Discharge (It)		506	8-2	29	0.0	265	528	35.50	32.48	0.07	0.13	160.0	55.0	7.3	60	
				3	29	0.0	280	628	41.53	38.4	0.05	0.0	137.5	67.5	7.3	76	
				4	29	0.0	255	715	41.33	38.0	0.05	0.2	132.5	66.0	7.2	80	
			Average		29	0	267	624	39.45	36.3	0.06	0.12	150.0	62.8	7.3	72	
		Raw Sewage		19	29	0	245	1288	34.36	30.8	0.03	0.15	147.5	62.5	7.0	124	
187	A68 Manhole #1			22				555									
	Manhole #2			22				607									
	Manhole #3			22				370									
		Avg July			27	0	213	669	39.57	34.53	0.02	0.15	130.0	52.5	6.6	100	

TABLE E-4

BACTERIOLOGICAL TEST RESULTS

Station Number	Stream	MPN Per 100 Milliliters					
		Coliform			Fecal Coliform		
		High	Low	Geometric Mean	High	Low	Geometric Mean
200	Bird Creek	240,000	70,000	120,340	79,000	28,000	39,040
142	Bird Creek	3,400	200	960	600	330	445
141	Hominy Creek	13,000	4,600	7,703	2,300	800	1,356
194	Bird Creek	22,100	800	4,425	10,900	500	2,323
191	Bird Creek	54,200	1,300	4,621	33,000	500	2,021
196	Caney River	49,000	4,900	16,044	13,000	4,900	6,783
144	Caney River	1,720	70	539	230	50	117
197	Caney River	2,210	490	810	170	140	154
199	Horsepen Creek	2,300	200	685	2,000	230	678
192	Caney River	2,300	330	929	800	170	369
193	Verdigris River	940	490	686	130	220	187
143	Verdigris River	80	23	51	50	8	24
190	Dog Creek	700	79	267	172	79	121
139	Verdigris River	330	23	115	200	23	71
209	Verdigris River	200	109	133	79	23	43
204	Coal Creek	490	80	171	490	60	148
205	Verdigris River	426	20	55	141	20	38
117	Arkansas River	7,900	2,200	4,400	4,900	2,200	2,873
154	Joe Creek	54,200	330	3,459	34,800	230	2,283
162	Polecat Creek	840	130	242	310	50	107
161	Posey Creek	790	20	173	330	20	113
160	Snake Creek	790	80	251	220	50	105
158	Haikey Creek	10,900	3,300	5,607	4,900	490	1,768
156	Broken Arrow Creek	54,200	1,750	14,889	7,000	700	2,885
207	Arkansas River	700	90	240	220	90	130
208	Arkansas River	109	23	50	17	2	6
138	Grand River	278	63	170	221	63	95
137	Arkansas River	70	23	29	50	5	16

APPENDIX "F"

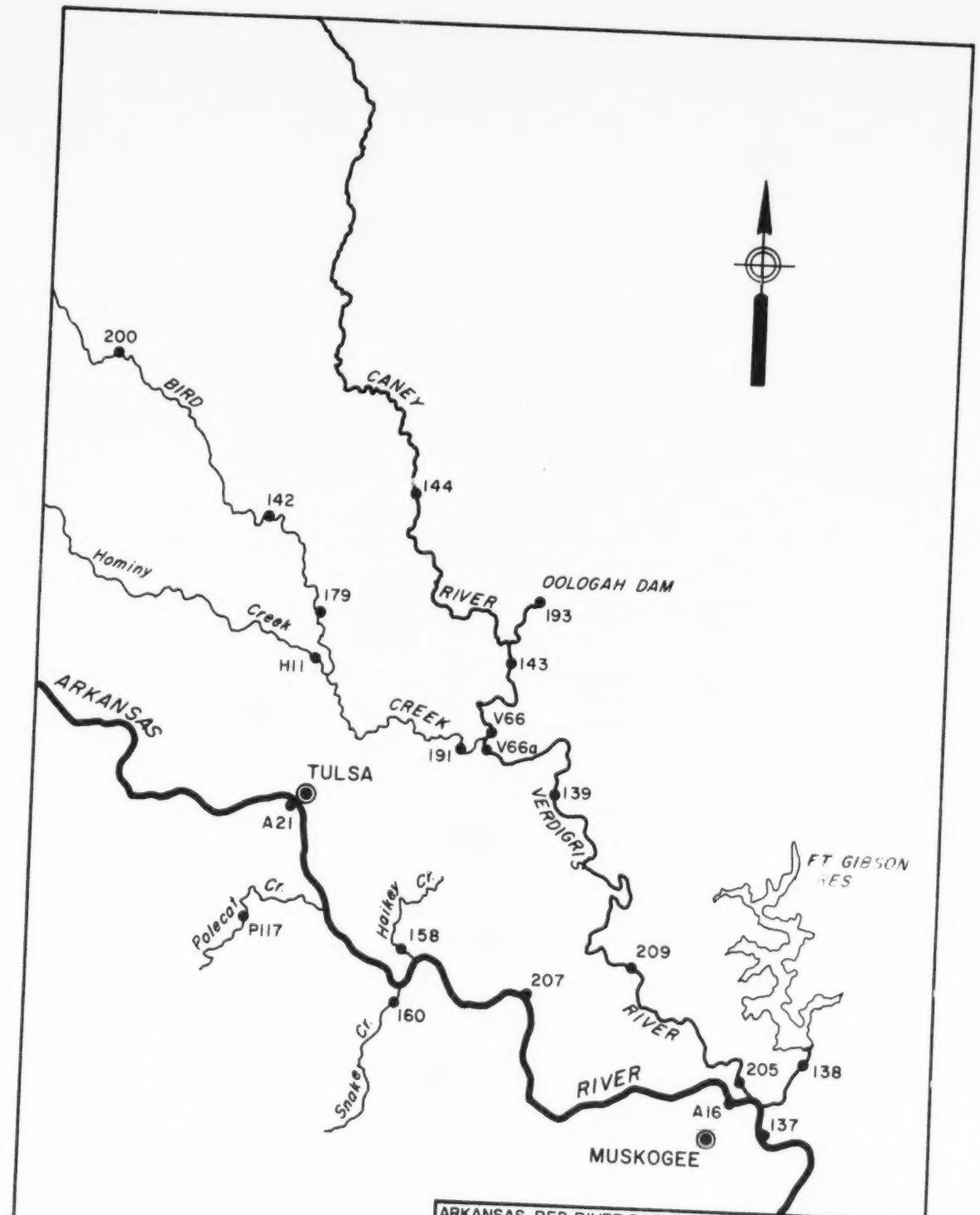
BENTHIC STUDY

Introduction - This survey was performed by personnel of the Robert S. Kerr Water Research Center in Ada, Oklahoma, in response to a request for technical assistance from the Arkansas-Red River Basins Comprehensive Project through the Dallas Regional Office. Sampling stations were selected where possible to coincide with those used for collection of chemical samples during the same period (Figure 8). The locations of stations used only for biological sampling are included on the data sheets. Each station was sampled on time between July 19 and August 6, 1965. Stations V66 and V66a were sampled again and a new station, B66 was sampled on October 6, 1965. Date, water temperature, and bottom type were observed and recorded at the time samples for benthic macroinvertebrates were collected.

A Surber square-foot sampler was used where the stream bottom was rocky and a Peterson dredge was used at other locations. All samples were sorted by the sugar floatation technique of Anderson 7/.

As suggested by Ingram and Bartsch 8/, sector diagrams were used to express biological conditions of the river system in the study area (Figure 9). Surber 9/, who used such diagrams to show the abundance of bottom animals which he groups as clean-water, facultative, and pollutional, states that probably "...only the use of 'facultative' requires explanation: facultative animals are those forms that are able to live in fairly heavily-polluted areas as well as in clean water situation."

Sector diagrams for Stations V66 and V66a consists of relative percentages of organism types in the samples collected October 6, 1965. Although the relative percentages for station V66 on this date were the same as those for earlier sampling date, the authors felt that the sample collected on October 6, was more representative of the conditions existing at station V66a. Relative percentages of organism types at the mouth of Bird Creek (station B66) were 50% clean, 50% facultative, and 0% pollutional.



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SAMPLING STATIONS — BENTHIC SURVEY

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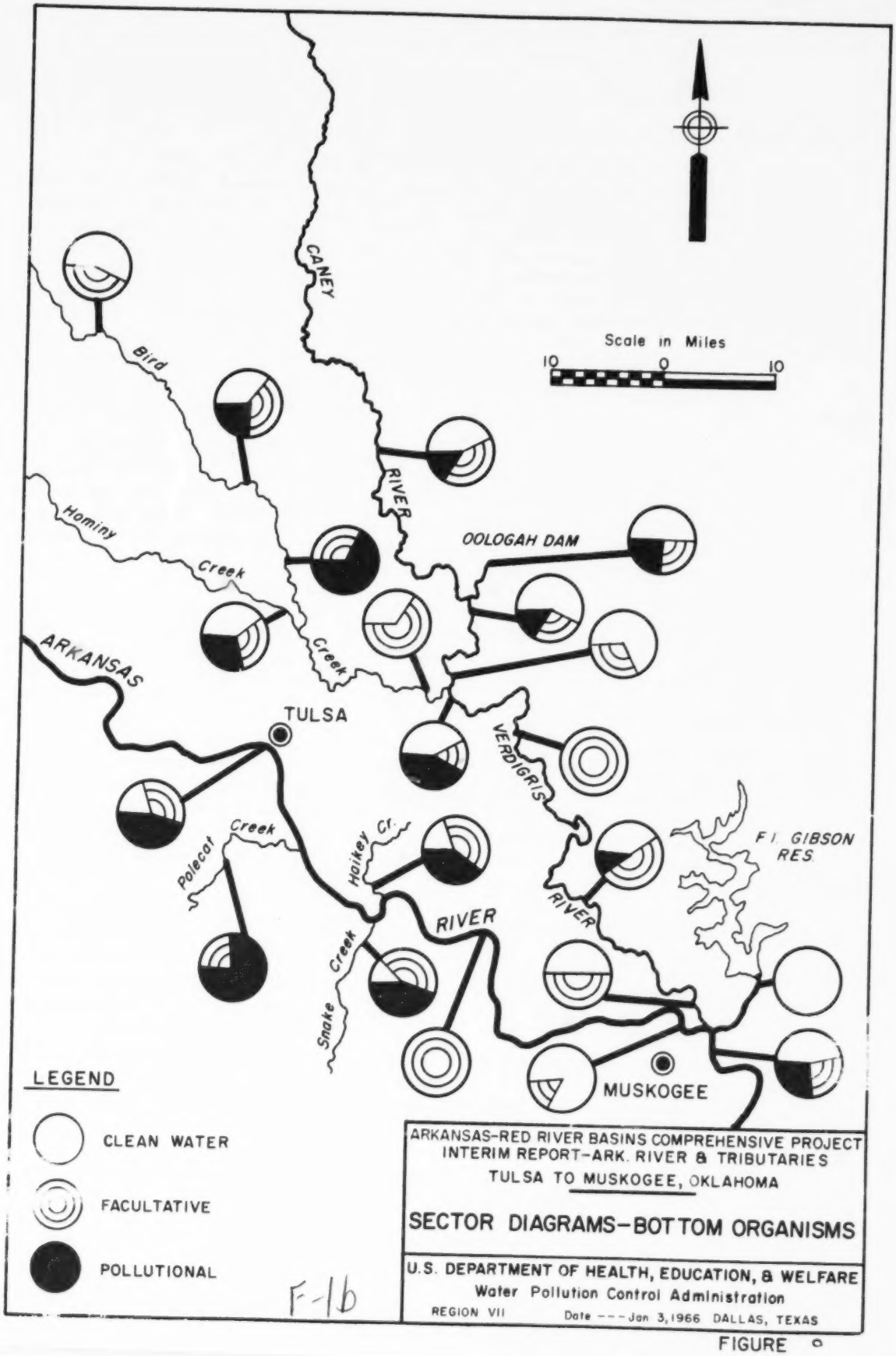
FIGURE 8


CANEY
Bird
RIVER
Hominy
Creek
OOLOGAH DAM
Creek
ARKANSAS
TULSA
VERDIGRIS
Polecat
Creek
Haikey Cr.
RIVER
RIVER
Ft. GIBSON
RES.
Snake
Creek
MUSKOGEE
Scale in Miles
10
0
10
LEGEND
CLEAN WATER
FACULTATIVE
POLLUTIONAL
F-1b
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SECTOR DIAGRAMS-BOTTOM ORGANISMS
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FIGURE 6

The "Biotic Index" used by Beck 10/ expresses biotic conditions as a single number. Index values of 10 or greater always indicate a clean stream. A grossly polluted stream will always have an index of zero, and a moderately polluted stream will have a biotic index of 1 to 6. A clean stream may rarely have an index which ranges from 4 to 9 if characterized by monotonous habitat and low velocity. The biotic index was used in this survey to indicate the cleanliness of sampling stations along the Arkansas and Verdigris Rivers and Bird Creek (Figures 10, 11, 12). Index values for stations V66, V66a, and B66 are based upon samples collected October 6, 1965. Table "E-1" gives the biotic index of tributaries where only one station was sampled.

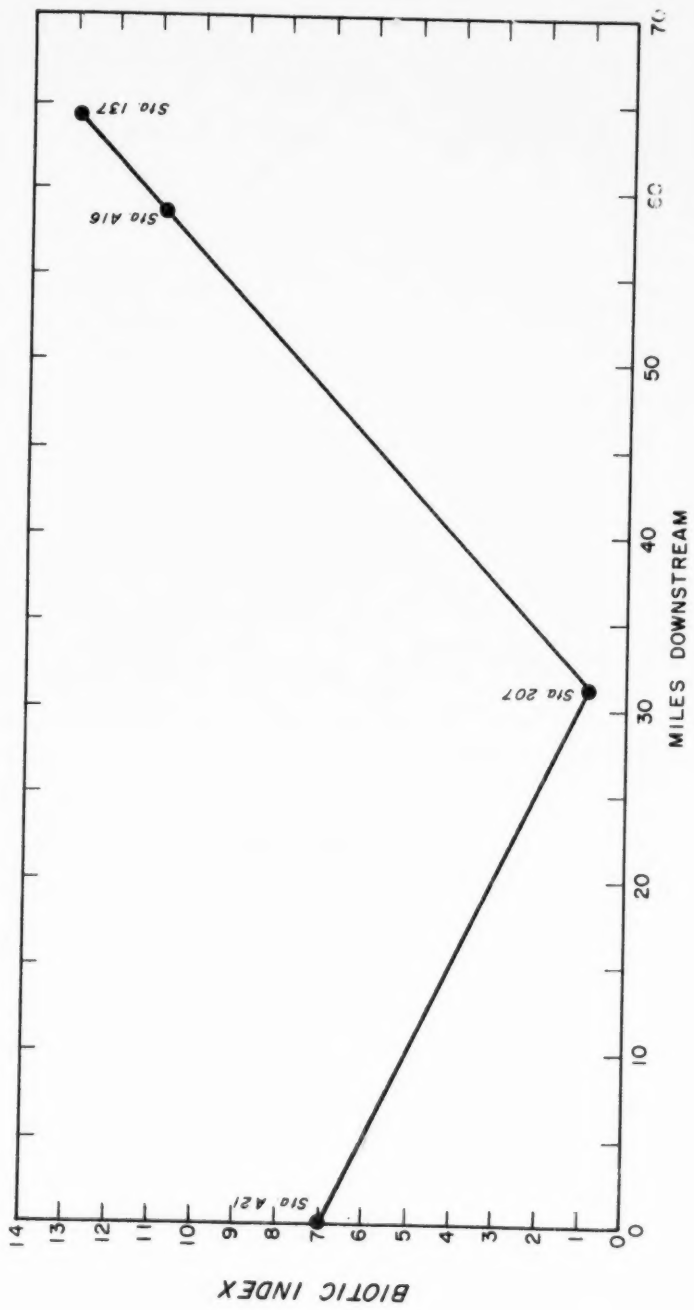
Findings - Figure 13 demonstrates the biotic variety among sampling stations indicating the variation in number of individuals and genera per area of bottom sampled. In general, Peterson dredge samples had fewer individuals and genera represented than those samples where the Surber square-foot sampler was used. These data indicated that similar benthic habitats are necessary for better comparison of the pollutional effect of stream water at the various sampling stations. In future biological surveys of the study area, consideration should be given to use of such techniques as the multiple-plate sampler for collection of bottom organisms. Such a sampler would provide the same opportunity for attachment for non-burrowing benthic organisms.

This survey was conducted during the season of the year that organic pollution would be likely to have its most adverse effect upon the benthic populations of organisms due to reduced stream flow, high water temperatures and low dissolved oxygen concentrations. However, nothing was observed that would indicate that stream conditions in the study area were different for this period of the year than would be found other years at this time.

Conclusions - Based on personal observation and evaluation of data including the biotic index, the effects of organic pollution on populations of benthic organisms have been used as follows to classify flows in the study area as clean, moderately polluted or very polluted.

Arkansas River - This flow is moderately polluted, beginning at 21st Street in Tulsa (Station #A21) and continuing for approximately 45 miles downstream. Farther downstream the water is clean.

Verdigris River - Beginning below the Oologah Dam (Station #193), this flow is clean for approximately 20 miles downstream. This river is moderately polluted for the next 35 miles. Farther downstream the water is clean.



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BIOTIC INDEX – ARKANSAS RIVER

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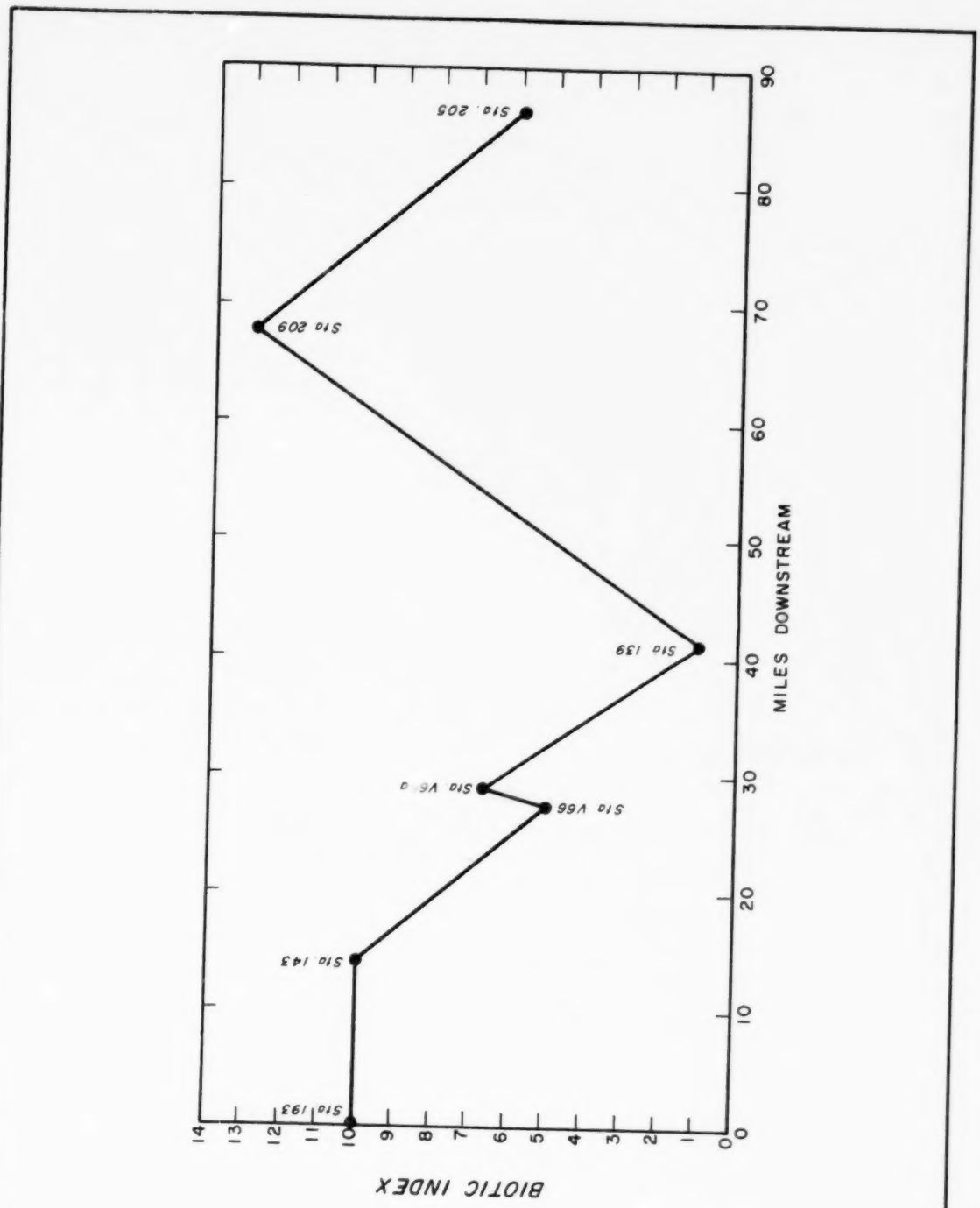
F-3a

FIGURE 10



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BIOTIC INDEX – VERDIGRIS RIVER

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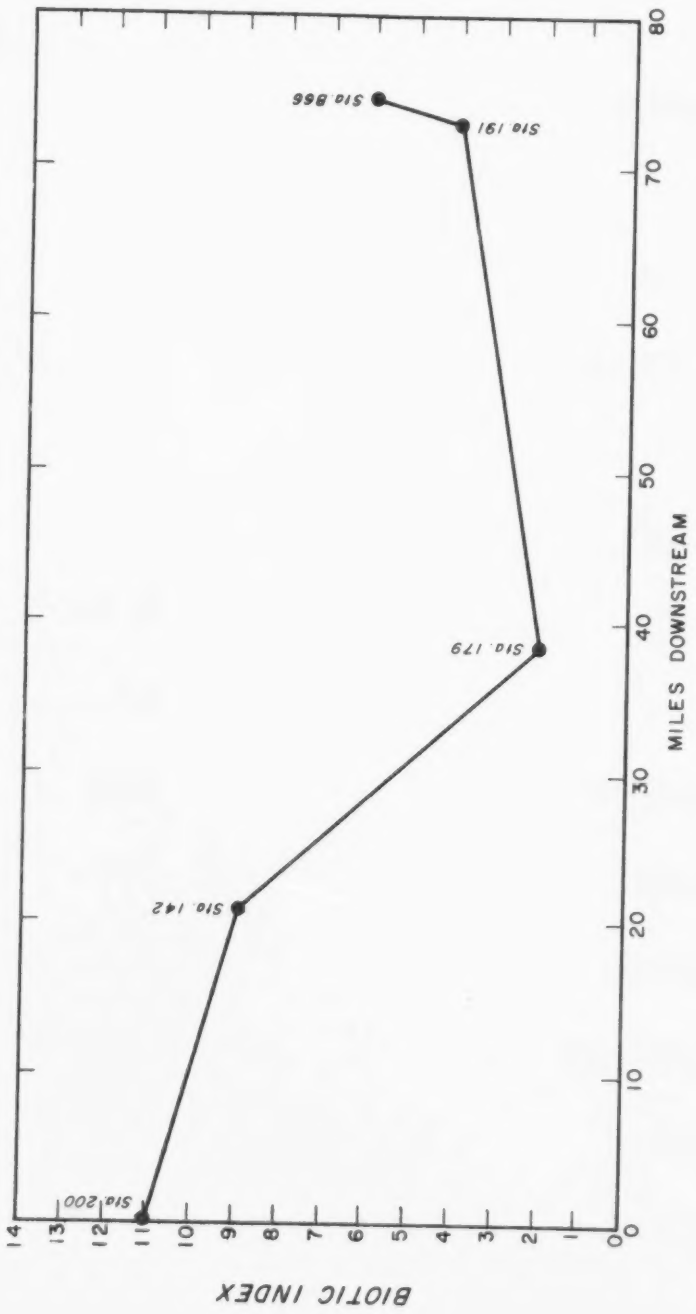
FIGURE 11



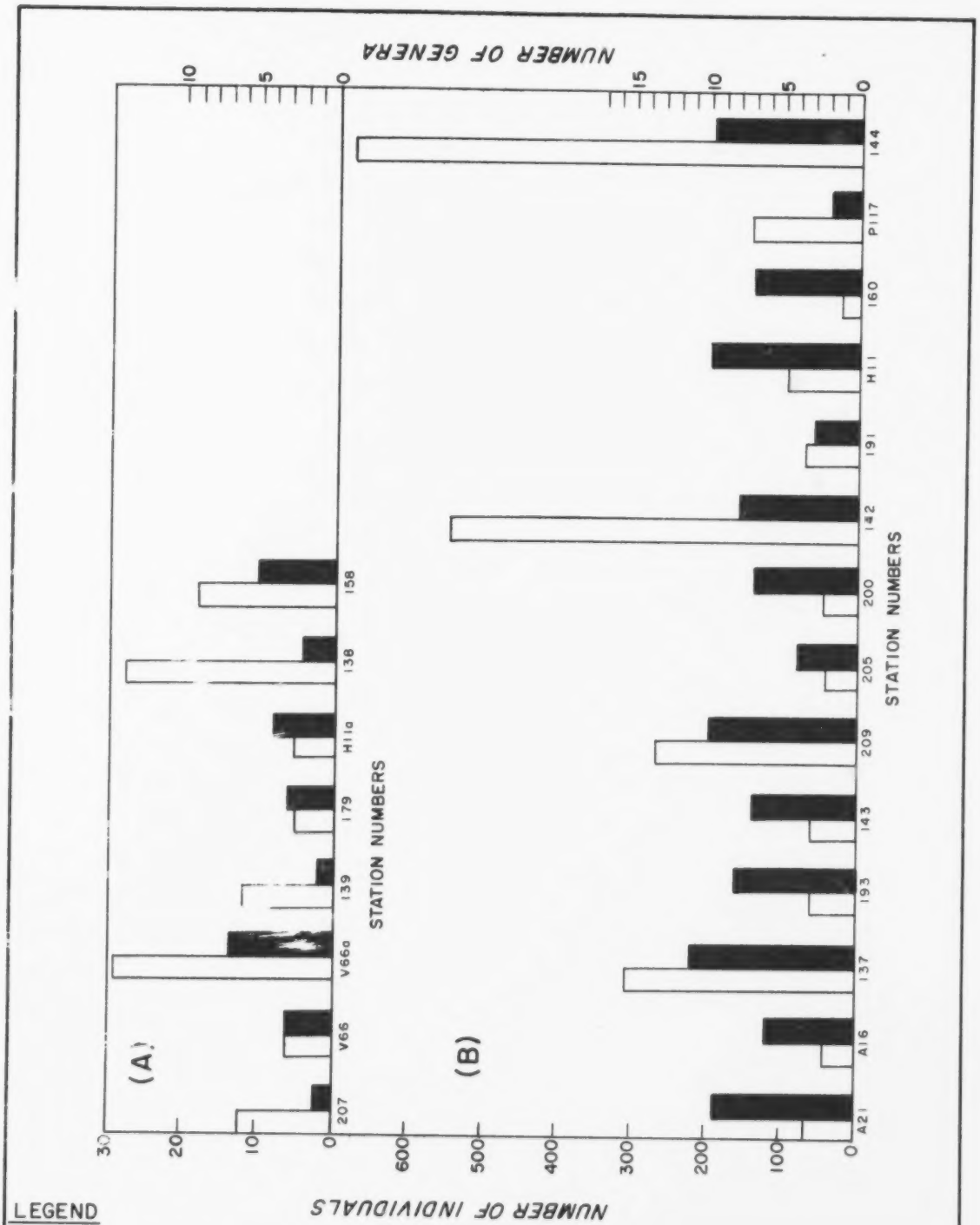
ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT-ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

BIOTIC INDEX—BIRD CREEK

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Water Pollution Control Administration
REGION VII Date --- Jan 3, 1966 DALLAS, TEXAS

F-3C

FIGURE 12



LEGEND

INDIVIDUALS

GENERA

(A) PETERSON DREDGE SAMPLES (95 sq. in.)

(B) SURBER SAMPLE (144 sq. in.)

F-3d

ARKANSAS-RED RIVER BASINS COMPREHENSIVE PROJECT
INTERIM REPORT - ARK. RIVER & TRIBUTARIES
TULSA TO MUSKOGEE, OKLAHOMA

BENTHIC ORGANISM COUNT

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Water Pollution Control Administration
REGION VII Date --- Jan 3, 1966 DALLAS, TEXAS

FIGURE 13

APPENDIX "F-1"

BIOTIC INDEX OF TRIBUTARIES

Tributary	Station Number	Biotic Index	Indicated Condition
Caney River	144	9	Clean
Grand Neosho River	138	4	Clean
Hominy Creek	H11	11	Clean
Polecat Creek	P117	1	Very polluted
Snake Creek	160	5	Moderately polluted
Haikey Creek	158	6	Moderately polluted

TABLE "F-2"

RESULTS OF BENTHIC SURVEY

Station No.: A21
Creek or River: Arkansas River
Location: 21st Street bridge, Tulsa
Type of Sample: Surber
Date: August 3, 1965
Water Temperature: 28° C
Bottom Type: Rocky

Organism	Type	Number
Diptera		
Pentaneura sp	Facultative	61
Tendipes sp	Pollutional	3
Atherix variegata Walker	Pollutional	1
Trichoptera		
Cheumatopsyche sp	Clean	1
Ephemeroptera		
Stenonema sp	Clean	1
Gastropoda		
Physa sp	Pollutional	1
Cladocera		
Daphnia sp	Facultative	1
Copepoda		
Argulus sp	Facultative	1
Hirudinea		
Illinobdella moorei Meyer	Pollutional	1
	TOTAL	71

Station No.: P117
Creek or River: Polecat Creek
Location: Highway 117 bridge, east of Sapulpa
Type of Sample: Surber
Date: August 3, 1965
Water Temperature: 26° C
Bottom Type: Rocky

Organism	Type	Number
Diptera		
Pentaneura sp	Facultative	129
Tendipes sp	Pollutional	14
Coleoptera		
Stenelmis sp	Pollutional	1
Gastropoda		
Physa sp	Pollutional	2
	TOTAL	146

Station No.: J60
Creek or River: Snake Creek
Type of Sample: Surber
Date: August 3, 1965
Water Temperature: 27° C
Bottom Type: Rocky

Organism	Type	Number
Ephemeroptera		
Stenonema sp	Clean	19
Odonata		
Ischnura sp	Facultative	1
Diptera		
Pentaneura sp	Facultative	1
Tendipes sp	Pollutional	1
Coleoptera		
Stenelmis sp	Pollutional	1
Cladocera		
Daphnia sp	Facultative	1
Hirudinea		
Helobdella sp	Pollutional	1
	TOTAL	27

Station No.: I58
Creek or River: Bailey Creek
Type of Sample: Peterson Dredge
Date: July 27, 1965
Water Temperature: 31° C
Bottom Type: Muddy

Organism	Type	Number
Annelida		
Helobdella sp	Pollutional	1
Odonata		
Sympetrum sp	Facultative	1
Ephemeroptera		
Tricorythodes sp	Clean	10
Diptera		
Pentaneura sp	Facultative	5
Trichoptera		
Macronemum sp	Clean	1
	TOTAL	18

Station No.: J07
Creek or River: Arkansas River
Type of Sample: Peterson Dredge
Date: July 27, 1965
Water Temperature: 32° C
Bottom Type: Sandy

Organism	Type	Number
Diptera		
Pentaneura sp	Facultative	12
	TOTAL	12

Station No.: A16
Creek or River: Arkansas River
Location: Highway 16 bridge, NE of Muskogee
Type of Sample: Surber
Date: July 23, 1965
Water Temperature: 32° C
Bottom Type: Sandy

Organism	Type	Number
Trichoptera		
Cheumatopsyche sp	Clean	11
Ephemeroptera		
Tricorythodes sp	Clean	1
Stenonema sp	Clean	11
Apyletria sp	Clean	1
Diptera		
Pentaneura sp	Facultative	12
Hydracarina (water mite)	Clean	1
	TOTAL	41

TABLE F-2 (Con't)

Station No.: 193
Creek or River: Verdigris River
Type of Sample: Surber
Date: July 22, 1965
Water Temperature: 27° C
Bottom Type: Rocky

Organism	Type	Number
Trichoptera		
Chematopsyche sp	Clean	42
Diptera		
Pentaneura sp	Facultative	4
Tendipes sp	Pollutional	7
Simulium sp	Facultative	1
Chaoborus sp	Clean	2
Ephemeroptera		
Tricorythodes sp	Clean	1
Ameletus sp	Clean	1
Crustacea		
Gammarus sp	Pollutional	1
	TOTAL	59

Station No.: 194
Creek or River: Canoe River
Type of Sample: Surber
Date: July 22, 1965
Water Temperature: 32° C
Bottom Type: Rocky

Organism	Type	Number
Megaloptera		
Corydalus cornutus L.	Facultative	11
Trichoptera		
Chematopsyche sp	Clean	579
Diptera		
Simulium sp	Facultative	61
Pentaneura sp	Facultative	3
Ephemeroptera		
Ameletus sp	Clean	14
Tricorythodes sp	Clean	3
Coleoptera		
Stenelmis sp	Pollutional	7
	TOTAL	679

Station No.: 123
Creek or River: Verdigris River
Type of Sample: Surber
Date: July 22, 1965
Water Temperature: 30° C
Bottom Type: Rocky

Organism	Type	Number
Ephemeroptera		
Stenonema sp	Clean	18
Tricorythodes sp	Clean	3
Ameletus sp	Clean	1
Trichoptera		
Chematopsyche sp	Clean	32
Megaloptera		
Corydalus cornutus L.	Facultative	1
Diptera		
Pentaneura sp	Facultative	1
Coleoptera		
Stenelmis sp	Pollutional	3
	TOTAL	61

Station No.: V66
Creek or River: Verdigris River
Location: Highway 66 bridge above Bird Creek
Type of Sample: Peterson Dredge
Date: October 6, 1965
Water Temperature: 20° C
Bottom Type: Rock and blue clay

Organism	Type	Number
Trichoptera		
Chematopsyche sp	Clean	4
Ephemeroptera		
Tricorythodes sp	Clean	1
Odonata		
Sompetrum sp	Facultative	1
	TOTAL	6

Station No.: V66
Creek or River: Verdigris River
Location: Highway 66 bridge above Bird Creek
Type of Sample: Peterson Dredge
Date: July 22, 1965
Water Temperature: 32° C
Bottom Type: Muddy

Organism	Type	Number
Diptera		
Peloptinae		
Pentaneura sp	Facultative	2
Ephemeroptera		
Caenis sp	Clean	2
Trichoptera		
Chematopsyche sp	Clean	2
	TOTAL	6

Station No.: 200
Creek or River: Bird Creek
Type of Sample: Surber
Date: July 16, 1965
Water Temperature: 30° C
Bottom Type: Gravel

Organism	Type	Number
Trichoptera		
Chematopsyche sp	Clean	17
Ephemeroptera		
Stenonema sp	Clean	2
Tricorythodes sp	Clean	1
Ameletus sp	Clean	1
Diptera		
Simulium sp	Facultative	1
Pentaneura sp	Facultative	4
Amphipoda		
Hyalella azteca (Saussure)	Facultative	27
	TOTAL	54

TABLE V-2 (Con't)

Station No.: 142
Creek or River: Bird Creek
Type of Sample: Surber
Date: July 22, 1965
Water Temperature: 30° C
Bottom Type: Rocky

Organism	Type	Number
Megaloptera		
Corydalus cornutus L.	Facultative	1
Trichoptera		
Chromatopsyche sp.	Clean	486
Coleoptera		
Stenelmis sp.	Pollutional	1
Ephemeroptera		
Ameletus sp.	Clean	28
Diptera		
Pentaneura sp.	Facultative	20
Simulium sp.	Facultative	1
Lepidoptera		
Elophila sp.	Clean	4
Mollusca		
Musculium sp.	Pollutional	2
	TOTAL	552

Station No.: 111
Creek or River: Hominy Creek
Location: Highway 11 Bridge
Type of Sample: Peterson Dredge
Date: July 22, 1965
Water Temperature: 27° C
Bottom Type: Muddy

Organism	Type	Number
Trichoptera		
Chromatopsyche sp.	Clean	2
Diptera		
Simulium sp.	Facultative	1
Coleoptera		
Stenelmis sp.	Pollutional	1
Ephemeroptera		
Stenonema sp.	Clean	2
	TOTAL	6

Station No.: 129
Creek or River: Bird Creek
Type of Sample: Peterson Dredge
Date: July 22, 1965
Water Temperature: 27° C
Bottom Type: Muddy

Organism	Type	Number
Coleoptera		
Stenelmis sp.	Pollutional	1
Pelecypoda		
Musculium sp.	Pollutional	1
Diptera		
Pentaneura sp.	Facultative	2
	TOTAL	4

Station No.: 101
Creek or River: Bird Creek
Type of Sample: Surber
Date: July 22, 1965
Water Temperature: 30° C
Bottom Type: Rocky

Organism	Type	Number
Isopoda		
Isotopus sp.	Facultative	1
Trichoptera		
Chromatopsyche sp.	Clean	1
Diptera		
Pentaneura sp.	Facultative	1
	TOTAL	3

Station No.: 111
Creek or River: Hominy Creek
Location: Highway 11 Bridge
Type of Sample: Surber
Date: July 22, 1965
Water Temperature: 27° C
Bottom Type: Gravel with scattered rocks

Organism	Type	Number
Decapoda		
Procambarus sp.	Facultative	1
Trichoptera		
Chromatopsyche sp.	Clean	23
Coleoptera		
Stenelmis sp.	Pollutional	12
Dytiscus sp.	Pollutional	1
Ephemeroptera		
Tricorythodes sp.	Clean	1
Stenonema sp.	Clean	1
Ameletus sp.	Clean	1
Diptera		
Pentaneura sp.	Facultative	1
Limnophora aequifrons Stein	Pollutional	1
Megaloptera		
Corydalus cornutus L.	Facultative	2
	TOTAL	102

Station No.: 106
Creek or River: Bird Creek
Location: Highway 99 Bridge
Type of Sample: Peterson Dredge
Date: October 5, 1965
Water Temperature: 20° C
Bottom Type: Muddy

Organism	Type	Number
Ephemeroptera		
Ephemera sp.	Clean	1
Diptera		
Chaoborus sp.	Clean	40
Pentaneura sp.	Facultative	1
Simulida		
(Unidentified Simuliidae)	Facultative	1
	TOTAL	43

TABLE F-2 (Con't)

Station No.: V46a
Creek or River: Ventigris River
Location: Highway 66 bridge below mouth of Bird Creek
Type of Sample: Peterson Dredge
Date: July 22, 1965
Water Temperature: 32° C
Bottom Type: Muddy

Organism	Type	Number
None		
	Facultative	12
	TOTAL	12

Station No.: V46a
Creek or River: Ventigris River
Location: Highway 66 bridge below mouth of Bird Creek
Type of Sample: Peterson Dredge
Date: October 6, 1965
Water Temperature: 20° C
Bottom Type: Rock and fine clay

Organism	Type	Number
Trichoptera		
Cheumatopsyche sp	Clean	21
Ephemeroptera		
Tricorythodes sp	Clean	1
Stenonema sp	Clean	1
Coleoptera		
Stenelmis sp	Polluted	2
Odonata:		
Tachopteryx sp	Facultative	2
Pelecypoda:		
Musculium sp	Polluted	1
Diptera:		
Chironomid sp	Polluted	1
	TOTAL	29

Station No.: 1-3
Creek or River: Ventigris River
Type of Sample: Peterson Dredge
Date: July 23, 1965
Water Temperature: 32° C
Bottom Type: Rocky

Organism	Type	Number
Diptera		
Psychomyia sp		8

Station No.: 203
Creek or River: Ventigris River
Type of Sample: Surber
Date: July 23, 1965
Water Temperature: 32° C
Bottom Type: Rocky

Organism	Type	Number
Trichoptera		
Cheumatopsyche sp	Clean	10
Ephemeroptera		
Baetisca sp	Clean	1
Diptera		
Pentaneura sp	Facultative	1
Simulium sp	Facultative	3
	TOTAL	15

Station No.: 205
Creek or River: Ventigris River
Type of Sample: Surber
Date: July 23, 1965
Water Temperature: 32° C
Bottom Type: Rocky

Organism	Type	Number
Megaloptera		
Corydalus cornutus L	Facultative	3
Trichoptera		
Cheumatopsyche sp	Clean	226
Ephemeroptera		
Stenonema sp	Clean	25
Baetisca sp	Clean	1
Tricorythodes sp	Clean	2
Diptera		
Pentaneura sp	Facultative	2
Simulium sp	Facultative	7
Gilospreta:		
Stenelmis sp	Polluted	8
Odonata:		
Tachopteryx sp	Facultative	1
Argia sp	Facultative	1
	TOTAL	278

Station No.: 136
Creek or River: Grand Saline
Type of Sample: Peterson Dredge
Date: July 27, 1965
Water Temperature: 30° C
Bottom Type: Rocky

Organism	Type	Number
Trichoptera		
Cheumatopsyche sp	Clean	1
Hydropsyche sp	Clean	27
	TOTAL	28

TABLE F-2 (Con't)

Station No.: 137
Creek or River: Arkansas River
Type of Sample: Surber
Date: July 27, 1965
Water Temperature: 12° C
Bottom Type: Rocky

Organism	Type	Number
Trichoptera		
Cheumatopsyche sp	Clean	250
Ephemeroptera		
Stenonema sp	Clean	7
Tricorythodes sp	Clean	5
Ameletus sp	Clean	2
Diptera		
Pentaneura sp	Facultative	39
Limnophora aequifrons Stein	Pollutional	2
Pericoma sp	Pollutional	2
Coleoptera		
Stenelmis sp	Pollutional	2
Megaloptera		
Corydalus cornutus L.	Facultative	1
Odonata: Zygoptera		
Ischnura sp	Facultative	1
Hydracarina (water mite)	Clean	1
	TOTAL	309

APPENDIX "G"

DETERMINATION OF DEOXYGENATION AND REAERATION RATE CONSTANTS

Deoxygenation (k_1) and reaeration (k_2) rate constants were calculated based upon the obtained D. O. and B.O.D. data. Each calculation consisted of two general and two specific determinations. Flow rate and velocity determinations were made where sufficient data were available. Stream velocities were then determined from these computations. k_1 determinations, based on results of laboratory analysis, were carried out by two methods. k_2 determinations were, in turn, based on observed and calculated values.

An "f" factor, the ratio of k_2:k_1, was assumed for each reach. Theoratic dissolved oxygen (D.O.) concentrations were computed using the assumed k_2's in the equation:

$$D = \frac{k_1 La}{k_2 - k_1} \quad 10^{-k_1 t} \quad - 10^{-k_2 t} \quad + Da\ 10^{-k_2 t}$$

Where:

D = Dissolved oxygen deficit from saturation

k_1 = Oxygen depletion constant at 20°C

La = Initial ultimate first stage BOD

t = Time in days

Da = Initial dissolved oxygen deficit from saturation were determined. 11/

The assumed "f" was then adjusted after comparison with D.O. and deficit values obtained by field analysis. Due to supersaturation concentrations of D.O. in the Arkansas River, computation of k_2 by this method was not possible. O'Conner and Dobbins' formula was used,

$$k_2 = \frac{480 D_L^{\frac{1}{2}} S^{\frac{1}{4}}}{H^{5/4}}$$

where; D_L = 0.00008ft.^{2}/hr., S = slope of stream, and H = effective depth.

1. Initial Flow Determination - A schematic diagram (Fig. 7) of the entire study area was prepared locating all USGS flow gages on the rivers. Records obtained for July 1965 flows at the various gages were averaged to obtain the results used in the computations. Since an apparent inconsistency was noted in that the Inola flow was less than the combined flows recorded at Sperry and Claremore, it was decided not to include the July 15th and 16th gage records at Avant and Sperry which were abnormally high. It is unlikely that a decreasing flow would be present in these stream reaches.

A straight line method of interpolatuion was used to compute river flows at intermediate points.

Example - Compute Verdigris River flow at mile 63.5 below Bird Creek.

Inola Q(mile 48.8) = 940 CFS

Claremore Q(mile $\frac{76.0}{27.2}$) = $\frac{834}{106}$ CFS - 85 (Bird Creek) = 21 CFS

$\frac{21}{27.2}$ = .772 CFS/mile flow increase

834 + (76.0 - 63.5) (.772) = 844 CFS above Bird Creek
+ 85 CFS from Bird Creek
929 CFS below Bird Creek

It should be noted that a flow decrease was observed on the Arkansas and Grand Rivers and the lower portion of the Verdigris.

2. Velocity Determinations

a. Velocities on the Arkansas and Verdigris Rivers were determined from a Q/A computation at various cross sections. The cross sectional areas used in the computations were found by planimetering river cross sections obtained from the U. S. Army Corps of Engineers office in Tulsa. Water level elevations were set from a plot of the hydraulic gradient obtained from July 1965 average gage records.

Example - Determine velocity of Verdigris River below Bird Creek.

Area from cross section at mile 63.1 = 3160 sq. ft.

Q at this section (from example 1) = 929 CFS

$$V = \frac{929}{3160} = .294 \text{ ft/sec.}$$

Example - Determine the average velocity of the Verdigris River between Station 143 and Dog Creek.

This is done by first figuring velocities as above at the various intermediate points and then taking a weighted average.

Mile	V-ft/sec	Avg V-ft/sec	t (days)
76.0	1.25		
		1.21	.191
69.4	1.17		
		1.45	.163
64.6	1.72		
		1.00	.091
63.1	.29		
		1.16	.202
60.0	2.03		
		1.60	.334
55.0	1.17		
			.981

$$\text{Avg V} = \frac{76.0 - 55.0}{.981} = \frac{21}{.981} = 21.5 \text{ mi/day}$$

$$= 1.31 \text{ ft/sec}$$

b. The velocities on Bird Creek, Caney River, and the Grand Neosho River were estimated from observations at various points by PHS personnel. Velocities between observation points were determined as the average of the observed values at the end-points of a stream reach.

Example - Determine time of travel on Bird Creek between Stations 187 and 142. V at Station 187 = 1.0 ft/sec, V at Station 142 = 2.0 ft/sec.

$$V = \frac{1.0 + 2.0}{2} = 1.5 \text{ ft/sec} = 24.6 \text{ mi/day}$$

$$t = \frac{60.0 - 54.2}{24.6} = .236 \text{ days}$$

APPENDIX "G"

TABLE "G-1"

DEOXYGENATION RATES DETERMINED FROM BOD ANALYSES

K_1	Values for 1,2,3 day BOD's		Values for 1,2,3,4 day BOD's		Values for 1,2,3,4,5 day BOD's		Values for 1 thru 6 day BOD's		Values for 1 thru 7 day BOD's		Values for 1 thru 8 day BOD's		Values for 1 thru 9 day BOD's		Values for 1 thru 10 day BOD's		K_1
	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	$\Sigma\frac{y}{L}$	$\frac{\Sigma y}{\Sigma(y\cdot t)}$	
.02	.2620	.4309	.4303	.3359	.6359	.2754	.8774	.2335	1.1529	.2027	1.4611	.1792	1.8004	.1607	2.1694	.1456	.02
.04	.4976	.4332	.8058	.3384	1.1749	.2780	1.5994	.2361	2.0746	.2054	2.5960	.1819	3.1595	.1633	3.7614	.1483	.04
.06	.7098	.4355	1.1343	.3408	1.6331	.2805	2.1966	.2387	2.8164	.2080	3.4853	.1845	4.1969	.1659	4.9457	.1509	.06
.08	.9010	.4377	1.4223	.3432	2.0242	.2830	2.6931	.2412	3.4177	.2105	4.1886	.1869	4.9980	.1683	5.8396	.1532	.08
.10	1.0735	.4399	1.6754	.3456	2.3592	.2854	3.1080	.2436	3.9085	.2128	4.7500	.1893	5.6241	.1706	6.5241	.1555	.10
.12	1.2295	.4421	1.8983	.3479	2.6471	.2877	3.4566	.2459	4.3121	.2151	5.2024	.1915	6.1192	.1728	7.0561	.1575	.12
.14	1.3706	.4442	2.0951	.3501	2.8956	.2900	3.7511	.2481	4.6464	.2173	5.5705	.1936	6.5155	.1748	7.4757	.1594	.14
.16	1.4984	.4463	2.2693	.3523	3.1108	.2921	4.0012	.2502	4.9253	.2193	5.8728	.1955	6.8365	.1766	7.8114	.1612	.16
.18	1.6144	.4483	2.4238	.3544	3.2979	.2942	4.2148	.2522	5.1598	.2212	6.1235	.1973	7.0995	.1783	8.0837	.1628	.18
.20	1.7197	.4503	2.5613	.3565	3.4613	.2962	4.3982	.2541	5.3584	.2230	6.3332	.1990	7.3174	.1799	8.3074	.1642	.20
.22	1.8156	.4522	2.6838	.3584	3.6043	.2981	4.5565	.2559	5.5276	.2247	6.5102	.2005	7.4998	.1813	8.4935	.1655	.22
.24	1.9029	.4541	2.7932	.3603	3.7301	.2999	4.6938	.2576	5.6729	.2263	6.6609	.2020	7.6540	.1826	8.6500	.1667	.24
.26	1.9825	.4559	2.8913	.3621	3.8412	.3017	4.8136	.2592	5.7985	.2277	6.7902	.2033	7.7856	.1838	8.7831	.1678	.26
.28	2.0552	.4577	2.9794	.3639	3.9396	.3033	4.9187	.2608	5.9077	.2291	6.9019	.2046	7.8989	.1849	8.8973	.1688	.28
.30	2.1217	.4594	3.0586	.3656	4.0270	.3049	5.0112	.2622	6.0032	.2304	6.9992	.2057	7.9972	.1859	8.9962	.1697	.30
.32	2.1826	.4610	3.1302	.3672	4.1050	.3064	5.0930	.2635	6.0873	.2316	7.0845	.2068	8.0832	.1869	9.0826	.1706	.32
.34	2.2385	.4626	3.1948	.3688	4.1749	.3078	5.1658	.2648	6.1616	.2327	7.1597	.2077	8.1588	.1877	9.1584	.1713	.34
.36	2.2898	.4642	3.2535	.3702	4.2376	.3091	5.2307	.2660	6.2277	.2337	7.2263	.2086	8.2258	.1885	9.2255	.1720	.36
.38	2.3369	.4657	3.3067	.3716	4.2941	.3104	5.2889	.2671	6.2867	.2347	7.2858	.2095	8.2854	.1893	9.2852	.1727	.38
.40	2.3803	.4671	3.3552	.3730	4.3452	.3116	5.3412	.2681	6.3396	.2356	7.3390	.2103	8.3387	.1899	9.3386	.1733	.40
.42	2.4203	.4685	3.3994	.3743	4.3915	.3127	5.3885	.2691	6.3873	.2364	7.3869	.2110	8.3867	.1906	9.3866	.1738	.42
.44	2.4572	.4699	3.4399	.3755	4.4335	.3138	5.4313	.2700	6.4304	.2372	7.4301	.2116	8.4300	.1911	9.4300	.1743	.44
.46	2.4913	.4712	3.4769	.3767	4.4719	.3148	5.4701	.2709	6.4695	.2379	7.4693	.2123	8.4693	.1917	9.4692	.1747	.46
.48	2.5229	.4724	3.5109	.3778	4.5069	.3158	5.5056	.2717	6.5052	.2386	7.5050	.2128	8.5050	.1922	9.5049	.1752	.48
.50	2.5521	.4736	3.5421	.3789	4.5390	.3167	5.5380	.2724	6.5377	.2393	7.5376	.2134	8.5375	.1926	9.5375	.1756	.50

Source: Professor Quinton B. Graves, Oklahoma State University, Stillwater, Oklahoma

3. Determination of k_1 values

a. Bird Creek

(1) Samples taken at Stations 191 and 194 were analyzed for long term BOD determinations which were used to compute k_1 by each of the following methods:

(a) Moment Method 12/

Example - Calculate k_1 for Station 191. First plot BOD concentrations arithmetically against time then fit a smooth curve through the points. Next tabulate the BOC values read from the curve and perform the following computations:

Time (days)	c	ct
0	0	0
1	1.0	1.0
2	1.4	2.8
3	2.2	6.6
4	2.7	10.8
5	3.3	16.5
	Σ y = 10.6	Σ 37.7

Compute $\Sigma \frac{c}{ct} = \frac{10.6}{37.7} = .281$ Enter the Table G-1 with this value to get $k_1 = .06$

(b) Daily difference method - Using the BOD vs Time curve plotted on the previous page, plot the changes in concentration against the midpoint of the time interval as follows on a semi-logarithmic plot.

Time	Conc.	C
0	0	1.40
2	1.40	1.30
4	2.70	1.10
6	3.80	1.00
8	4.8	0.90
10	5.7	0.90
12	6.6	0.80
14	7.4	0.65
16	8.05	0.65
18	8.60	0.55
20	9.00	0.40

Determine k_1 from reading the slope of the straight line fitted through the plotted points.

$$k_1 = \frac{\log_{10} (3.3/0.98)}{20} = \frac{.528}{20} = .0264$$

The average k_1 of the moment and daily difference methods of calculation then is:

$$k_1 = \frac{.06 + .0264}{2} = .0432$$

(2) Using the values of k_1, thus computed at the stations where long term BOD tests were run, ultimate BOD values, L, were calculated from the deoxygenation equation.

Example - compute L at Station 191

$$L = \frac{5 \text{ day BOD}}{1 - 10^{-5k_1}} = \frac{1820\#}{1 - 10^{-5(.0432)}} = 3520\#$$

Since it is apparent that the k_1 values thus obtained are point values only and do not necessarily hold true for all points in the stream reach lying between sample points, a check was run between the observed L values as determined above and the expected BOD remaining computed from the use of actual stream flow conditions. If the comparison was not good, k_1 was adjusted accordingly.

Example - Determine the value of k_1 for the various reaches of Bird Creek between Stations 142 and 194. Assume that k_1 and L values measures at Station 194 are representative since there is no immediate pollution source upstream and the mixing should be fairly complete. The flow here should also be nearly correct since there is a flow gage nearby.

k_1 (average of moment and daily difference computation) = .138

L = 1290 lbx BOD

Assume (after trail) that k_1 of Bird Creek at the Hominy Creek mouth is .0581. The average k_1 for this stream reach is then $\frac{.138 + .0581}{2} = .0979$. Time of flow from Hominy Creek mouth to Station 194 = .488 days. Working upstream from Station 194, L at Hominy Creek mouth = $\frac{1290}{10^{-k_1 t}} = \frac{1290}{10^{-(.0979)(.488)}} = 1300\#$.

But 10# of this is contributed by Hominy Creek so L in Bird Creek above the Hominy Creek discharge is 1300 - 10 = 1290#. From Station 142 to Hominy Creek mouth, the time of flow is 1.08 days. Assuming the k_1 value of Bird Creek to remain constant at .0581 between Station 142 and Hominy Creek, L at Station 142 =

$\frac{1290}{10^{-.0581\ (5)}}$ = 1490# . This value may be checked by computing the L value at Station 142 obtained from the 5 day BOD test results. $L = \frac{733}{10^{-.0581(5)}}$ = 1500# . The comparison is good therefore, k_1 is assumed to be correst.

b. Caney River - A similar procedure was followed assuming the L and k_1 values at Station 196 as representative for the starting point. Note that 5 day BOD test values were weighted at Station 197 and 192.

c. Verdigris River - The procedure described was followed for the portion of the Verdigris River lying upstream from Station 139. A weighted average for 5 day BOD at Station 143 was used. Below this point, however, test values of BOD ran considerably higher than expected values computed from actual stream conditions indicating additional pollutional loading from an undetermined source.

d. Arkansas River - Same procedure was followed and checks appeared to be good.

4. Determination of k_2 values.

The first step involves conversion of test D.O. values to equivalent values at 20° C.

Example - Determine the oxygen deficit at Station 193 on the Verdigris River. Test D. O. = 6.8 ppm @ 28.3° C. 7.92-(7.92-7.77) x .3 = 7.87 ppm = Saturation values of O_2 in water @ 28.3°C.

$\frac{6.8}{7.87}$ = 86.3% Saturated

Saturation at 20° C = 9.17 ppm

9.17 x 86.3% = 7.92 ppm @ 20° C

9.17 - 7.92 = 1.25 deficit

The deficits, as converted, were then used in the oxygen sag equation along with the previously computed k_1 and L values to determine the k_2 values for successive stream reaches.

Example - Determine k_2 in Bird Creek between stations 142 and 194.

$$D_B = \frac{L_A \ k_1}{k_2 - k_1} \left(10^{-k_1 t} - 10^{-k_2 t} \right) + D_A \ 10^{-k_2 t}$$

$$D_B = \frac{L}{f-1} \left(10^{-k_1 t} - 10^{-f \ k_1 t} \right) + D_A \ 10^{-f \ k_1 t}$$

$$\text{Where } f = \frac{k_2}{k_1}$$

Try f = 4.0 Typical for swift stream from Fair & Geyer, Water Supply & Waste Water Disposal (1954) 12/

$$D_B = \frac{6.7}{3} \left(10^{-.0583(1.08)} - 10^{-4(.0582)(1.08)} \right) + .16 \times 10^{-4(.0582)(1.08)}$$

$D_B = .680 + .090 = .770$ @ Hominy Creek

$$D_{194} = \frac{4.3}{3} \left(10^{-.0981 \ (.488)} - 10^{-4(.0981)(4.88)} \right) + .770^{-3(.0981) \ (.488)}$$

$D_{194} = .361 + .495 = .856$ - Check vs. .74 observed value - o.k.

$k_2 = fk_1 = 4 \times .0582 = .232$

The k_2 values for Bird Creek and the Caney River were determined by the above described method. k_2 values on the Arkansas and Lower Verdigris Rivers were not determinable in the manner since super-saturation of dissolved oxygen appeared in a number of places. Resort was then made to the formulas developed by O'Connor and Dobbins.

$$k_2 = \frac{(D_L U)^{\frac{1}{2}}}{2.31 \ h} \quad 3/2 \quad \text{(for effective depths of 5' or greater)}$$

where U = velocity in ft/day

k_2 = reaeration constant per day @ 20°C

h - effective depth

D_L = molecular diffusitivy constant = .00195 ft ^{2}/day oxygen in water

$$k_2 = \frac{480\ D_L^{\frac{1}{2}}\ S^{\frac{1}{4}}}{h\ 5/4}$$ (for effective depth less than 5'

where S = Slope in ft. per ft, D_L = .00008 ft^2 / hr O_2 in water.

Other factors are the same as for previous equation.

Effective depths were calculated by dividing the volume of water in a stream reach by the surface area of the water in that reach. All figures were taken from the same river cross section used for the initial flow determinations.

Example - find k_2 in Verdigris River between Stations 139 and 209.

$$h = \frac{\text{Avg cross sec area}}{\text{Avg cross sec width}} = \frac{\Sigma A}{\Sigma W}$$ of all cross sections between Stations 139 and 209.

$$h = \frac{1160 + 1320 + 718 + 831 + 1940 + 2240 + 1340}{130 + 135 + 105 + 140 + 185 + 205 + 135}$$

$h = 9.23'$ $\qquad u = \frac{26.5 \times 5280}{1.90} = 73{,}600$

$$k_2 = \frac{\left((.00195)(73600)\right)^{\frac{1}{2}}}{2.31\ (9.23)^{3/2}} = .185$$

k_2 values predicted for the proposed channel modifications were also computed by use of the formulas developed by O'Conner and Dobbins

APPENDIX "H"

OCCURENCE AND EFFECT OF ALGAE NUSIANCES*

The algae constitue a group of life forms that may be unicellular or multicelluar, motile or immoble, of which practically all have photosynthetic pigments. They can be beneficial to waters because they add oxygen, remove carbon dioxide, are significant in self-purification processes, and serve as food for certain aquatic fauna. However, since algae utilize inorganic materials such as phosphate, ammonia, nitrate, and carbon dioxide which are then photosynthetically transformed into cellular organic materials and oxygen, the algae should be considered as producers rather than destroyers of organic matter.

Growth or types are reported to be influenced by pH, turbidity, sunlight, sulfates, temperature, water velocity, silica, nitrates, carbonates, phophates, and manganese. Phosphorus and nitrate are most often mentioned as critical factors in algal growths. For some algae, N:P ratios of 30:1 were found to be optimal; for others 15-18:1 seem to be favorable. When inorganic nitrogen and phosphorus exceed 0:3 and 0.01-0.015 mg/l respectively at the start of the growing season, nuisance blooms of algae have generally been observed to occur.

Three pollution conditions can result from algae blooms: (1) algae toxicity; (2) esthetic harms, including production of testes and odors; and (3) buildup of a BOD. The following damages can result from an over-abundance of algae:

1. Municipal and industrial water supply

    a. Taste and odor
    b. Color and turbidity
    c. Reduced capacity in holding reservoirs due to bottom buildup
    d. Clogging of intake screens and reduced transmission line capacity

2. Irrigation - Clogging of distribution system

3. Stock and Wildlife Watering - Killing various forms of wildlife (suspected)

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* All information in this Appendix obtained from Publication No. 3-A, "Water Quality Criteria", published by the California State Water Quality Control Board. 13/

4. Fish and other aquatic life

   a. Fish kills through direct poisoning
   b. Oxygen imbalance

5. Recreational use

   a. Destruction of esthetic values through unsightly appearance or
   b. Septic odors when decomposing

6. Nuisance conditions in turning basins and dock areas

APPENDIX "I"

GENERAL WATER QUALITY REQUIREMENTS BY USE*

1. Domestic Water Supply - The use of water by human beings for drinking and other domestic purposes is generally the primary, highest, or most essential use of water. However, other beneficial uses may have quality requirements far more stringent in various respects than those for drinking water. The Public Health Service (PHS) Drinking Water Standards of 1962, provide physical, chemical, and bacterial quality criteria for drinking water at the consumer's tap while PHS standards of quality in the stream are shown in Table "I-1" below.

TABLE "I-1"

PROMULGATED STANDARDS FOR RAW WATER SOURCES OF DOMESTIC WATER SUPPLY

BOD (5 day) mg/l	
Monthly average:	1.5-2.5
Maximum day, or sample:	3.0-4.0
Coliform MPN per 100 ml	
Monthly average:	50-5,000
Maximum day, or sample:	Less than 20% over 5,000
Dissolved Oxygen	
mg/l average:	4.0-6.5
% saturation:	60% or better
pH	
Average:	5.0-9.0
Chlorides, max. mg/l	50-250
Fluorides, mg/l	1.5-3.0
Phenolic compounds, max mg/l	0.005
Color, units	20-150
Turbidity, units	10-250

* Information in this Appendix obtained from Publication No. 3-A "Water Quality Criteria" 13/, published by the California State Water Quality Control Board, except where noted.

2. Industrial Water Use - The quality of water required for industrial use varies widely for the many purposes to which it is put. Thus, it is not practical to describe, in detail, the criteria for industrial water supply in this area. A major factor is that the characteristics of the stream water remain relatively constant, and that the quality not deteriorate with time, after the necessary treatment works have been placed in operation. Water is required which will not effect the product by decay (resulting from biological action), staining, corrosion, chemical reaction, and contamination; nor should it result in deterioration of equipment, reduction in efficiency, or capacity.

a. Cooling Water Only - Cooling waters should have appropriate initial temperatures and should not deposit scale, be corrosive, or encourage the growth of slimes. The importance of relatively constant quality from day to day, outweighs the absolute quality of cooling water supply.

3. Irrigation - Substances of concern in the quality of natural irrigation waters may be listed under the following three headings: (a) total salts, (b) substances found in low or trace concentration, and (c) specific cations and anions. The total salt concentration, the main effect of which is osmotic, is usually stated in terms of specific conductance. The substances found generally in low concentration include compounds of boron, silicon, fluorine, sulfur, phosphorus, iron and other elements; nitrate and amonium ions; hydrogen ion concentration; and organic matter. These substances contribute to the total osmotic effect; they are often essential, in limited amounts, for plant growth, and they are often toxic above certain concentrations. The cations, Ca^{++}, MG^{++}, NA^{+}, and K^{+}, and the anions CO_3^{--}, HCO_3^{-}, SO_4^{--}, CL^{-}, and NO_3, contribute to the total osmotic effect. Although these ions are essential for plant growth, they can be toxic above certain concentrations; therefore, they are important because of their detrimental effect upon the soil.

The characteristics of water, which have been accepted thus far as sufficient to determine its suitability for irrigation, are (a) the total concentration of salts, (b) Sodium Adsorption Ratio (SAR) which equals $Na^{\frac{1}{2}}\left(\frac{2Na\%}{100-NA\%}\right)^{\frac{1}{2}}$. The SAR can be expressed in terms of milliequivalents per liter of sodium and the sodium percentages (14) and (c) boron, chloride, and sulfate concentrations. These factors may all vary more or less independently, so that water adequate in several respects may be rendered unsuitable due to a

high concentration of one constituent, e.g. boron. The allowable concentration for several of the constituents including chlorides, solids and probably ABS will be controlled by plant sensitivity.

4. Stock and Wildlife Watering - Water safe for human consumption may be used safely by stock. Still, stock and wildlife appear to tolerate higher salimites than man. Algae may be toxic.

5. Propogation of Fish and Other Aquatic and Marine Life - In the absence of toxic substances or pollutants, the water described below and on the following page, is favorable, and not merely sublethal, for a mixed warm-water fish population and its organisms.

a. Dissolved oxygen not less than 5 mg/l;

b. pH, approximately 6.7 to 8.6 with an extreme range of 6.3 to 9.0;

c. Specific conductance at 25° C, 150 to 500 mho x 10^{-6}, with a maximum of 1000 to 2000 mho x 10^{-6} permissible for streams in western alkaline areas;

d. Free carbon dioxide, not over 3 cc per liter;

e. Ammonia, not over 1.5 mg/l;

f. Suspended solids such that the millionth intensity level for light penetration will not be less than 5 meters.

6. Swimming, Bathing, and other Water Contact Sports - To be acceptable to the public and the regulatory authorities, waters that are used for swimming and other water contact sports must conform to three general conditions:

a. They must be free from obnoxious floating or suspended substances, objectionable color and foul odors;

b. They must contain no substances in amounts which are toxic to human or are irritating to the skin; and

c. They must be reasonably free from pathogenic organisms.

In Table IV of the Water Quality Criteria for Oklahoma 14/the suggested objective for coliform bacteria for recreational use is 500 - 1000 coliform (MPN) for 100 milliliter.

Other values for recreational use from Table IV of the Water Quality Criteria for the State of Oklahoma are listed.

Algae, Standard Units, Vol.	Absence of Toxic Algae
Ammonia, ppm	0.3
Chromium, ppm	10.0
Coliform, MPN/100 ml	500 to 1000
Copper, ppm	1.0
Dissolved Oxygen, ppm	Over 4.0
Fluoride, ppm	5.0
Hydrogen Ion Concentration	5.0 to 9.5
Nitrate, ppm	44.0
Nitrogen, Total, ppm	10.0
Oil, ppm	0.3
Phenolic Compounds, ppm	0.2 to 1.0
Radioactivity, uc/l	Background
Suspended Solids	Absence of Sludge Deposits
Temperature, ^{o}F	32 to 95
Turbidity, ppm	2,000

7. Boating and Esthetic Enjoyment - Quality requirements for waters that are used for boating and esthetic enjoyment are similar to those for swimming, bathing, and water-contact sports, and those for fishing and wildlife. These three beneficial uses are normally compatible and frequently concurrent. In general, however, the water-quality criteris for boating and esthetic enjoyment are not as rigid or restrictive as those for actual water contact by humans, fish, or wild animals. Of the three conditions listed for swimming, for example, only the first applies to boating and esthetic enjoyment.

Conditions of water quality that affect boating and esthetic enjoyment are visible floating, suspended, or settled solids arising from the disposal of sewage or garbage; sludge banks, slime infestation; heavy growths of attached plants or animals; blooms or high concentrations of plankton; discoloration or excessive turbidity from sewage, industrial wastes, or even natural sources; the evolution of dissolved gases, especially hydrogen sulfide; visible oil or grease, including emulsions; excessive acidity or alkalinity that leads to corrosion or delignification of boats and docks; surfactants that form when the water is agitated or aerated; and excessive water temperatures that cause high rates of evaporation and cloudiness over the water.

8. Water Power and Navigation - The pollutants in water that interfere with its beneficial use for water power and navigation are; (a) substances such as acid, alkali, and excessive salinity that accelerate corrosion, cavitation, or delignification, (b) debris, silt, and other suspended solids that block channels and intake devices or settle in reservoirs to reduce their useful storage, (c) organic matter that generates putrescible odors and corrosive hydrogen sulfide gas in deep reservoirs, (d) algae, fungi, worms, barnacles, and other corollary pollutants that clog passageways, cling to vessels, or accelerate corrosion, (e) marine borers that destroy wharves and docks, and (f) floating oil that poses a potential fire hazard.

9. Transport, Dispersion, and Assimilations of Wastes - Waters used to dilute and assimilate the final effluent from waste treatment plants should have a low temperature and be rich in dissolved oxygen content. Beyond this, local conditions impose further restrictions depending upon the nature of the wastes and the use of the receiving waters as shown above.